

BGP in 2021



Geoff Huston
APNIC Labs



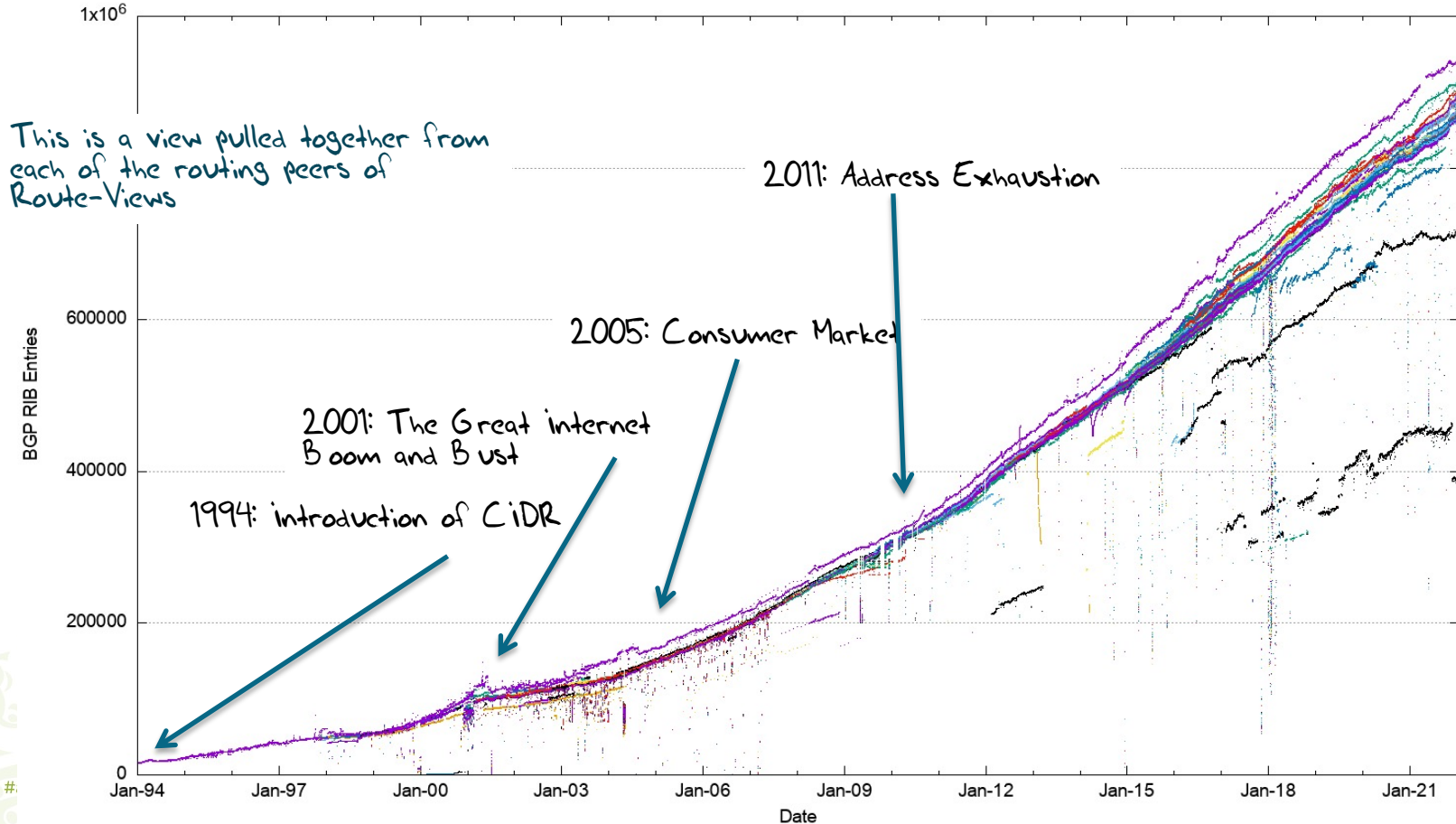
The Highlights

- IPv4 FIB Summary
- IPv6 FIB Summary
- FIB Projections
- Churn
- Conclusions

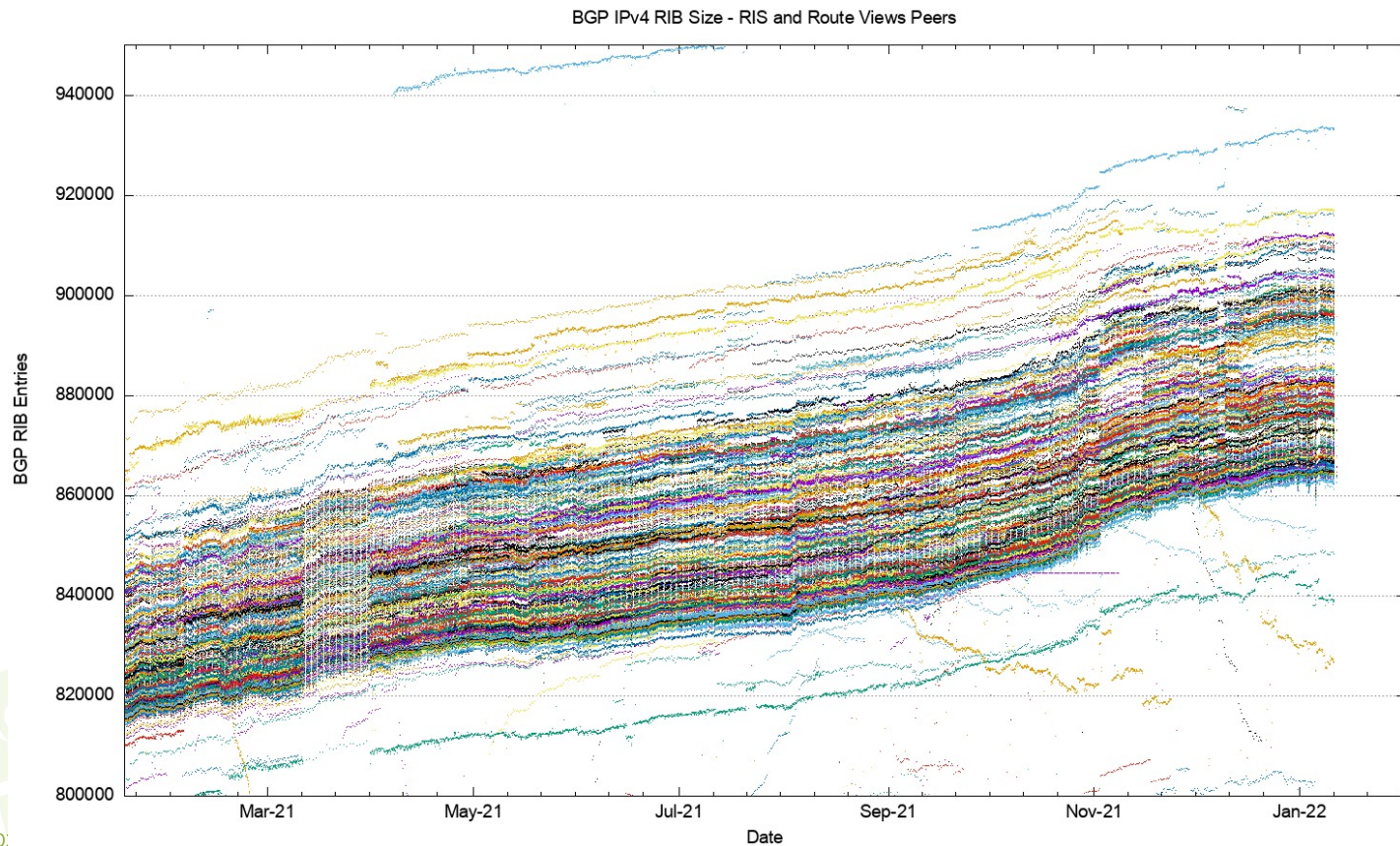


28 Years of Routing the Internet

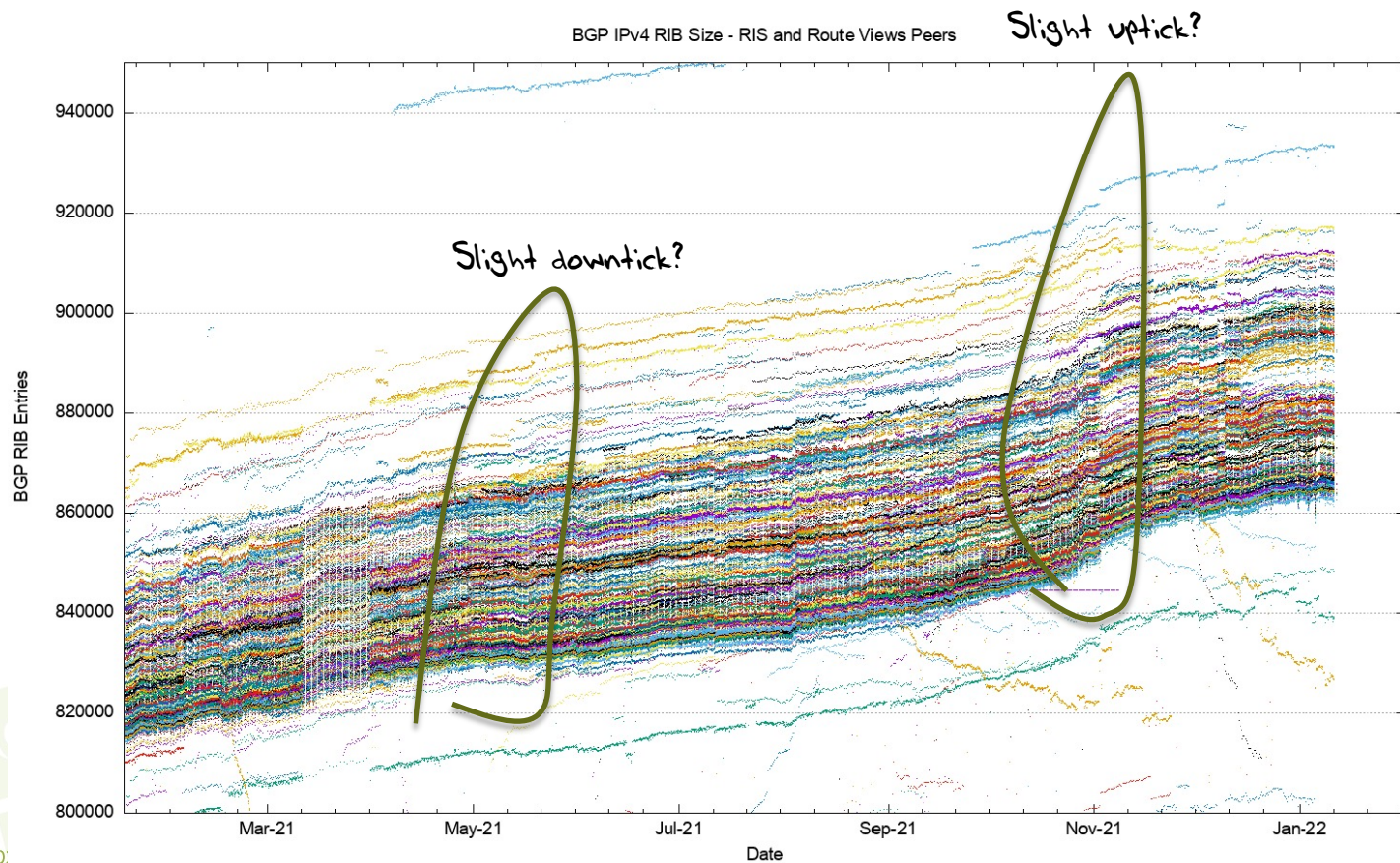
BGP IPv4 RIB Size - Route Views Peers



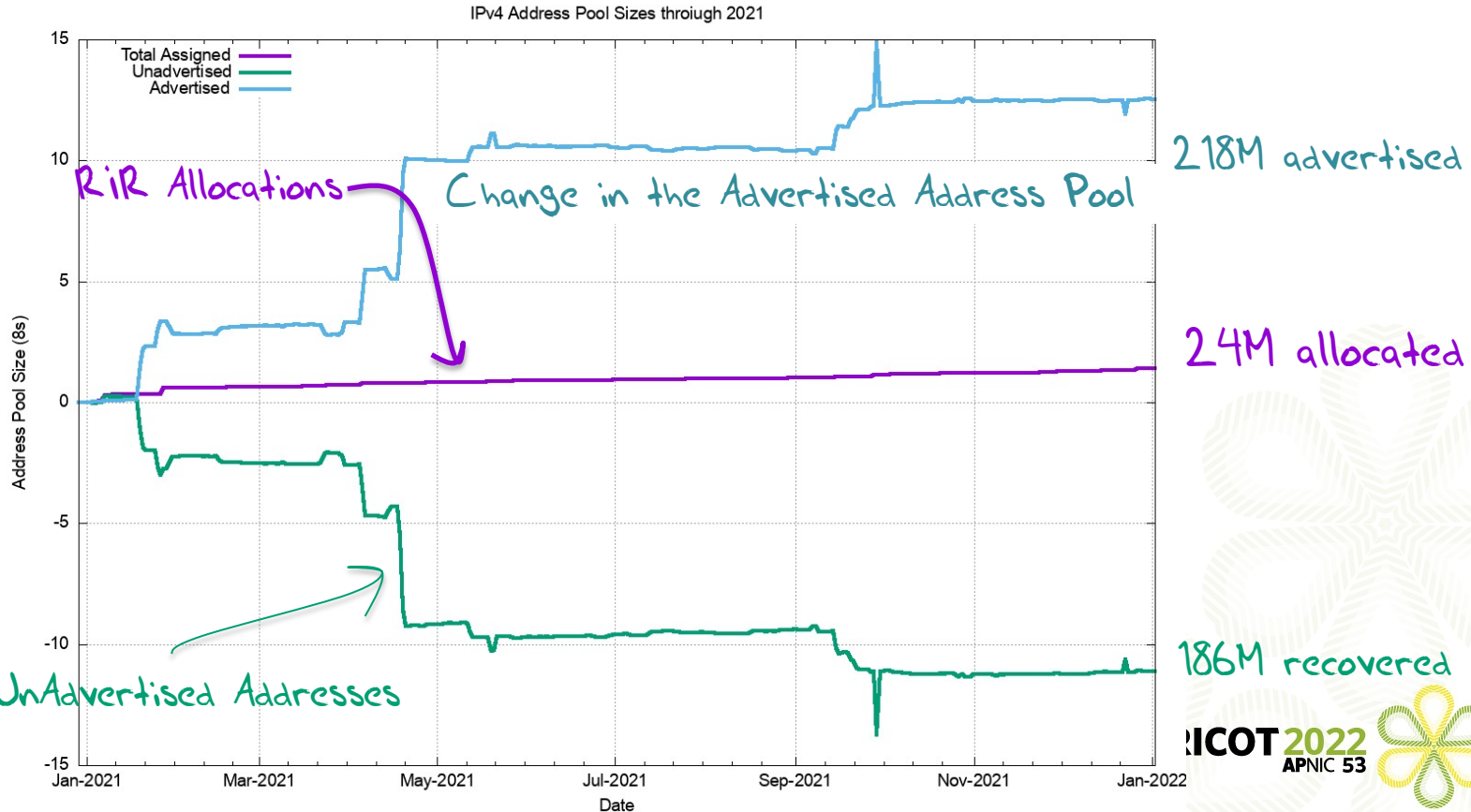
2021 in detail



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2021: Assigned vs Recovered



What happened in 2021 in V4?

- From the look of the routing growth plots, the growth of the size of the IPv4 network **is slowing down**
- The number of entries in the IPv4 default-free zone reached 906,000 by the end of 2021
- The pace of growth of the routing table was slightly lower than the rolling 5-year average, with **40,000 new entries in 2021** (was 52,000 in 2020)
- The AS position was slightly lower with **2,400 new AS's advertised in 2021** (was 3,400 in 2020)
- Transit relationships have not changed materially over 2021 for most networks
- **The overall growth trends are slowing down in 2021**

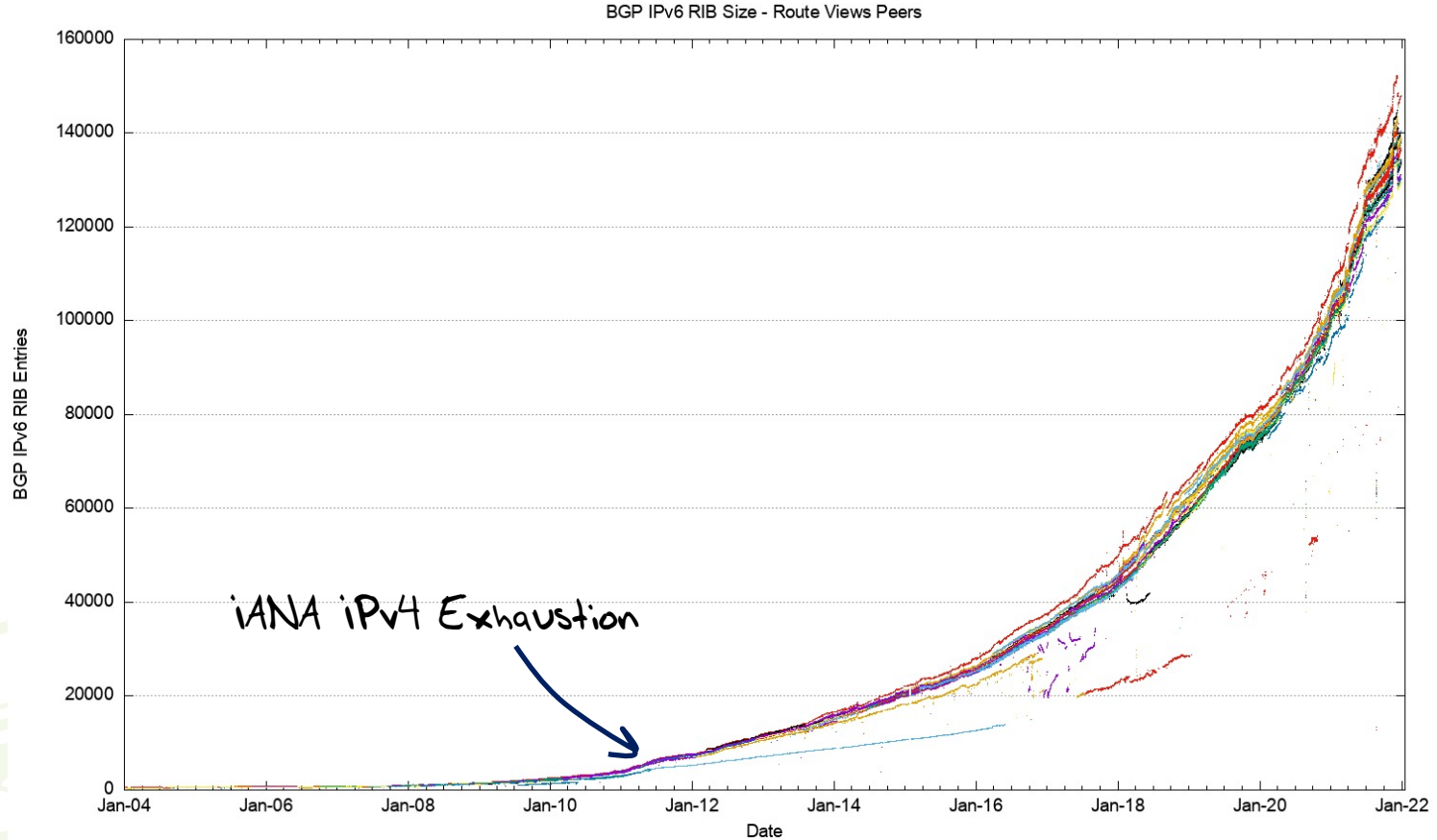


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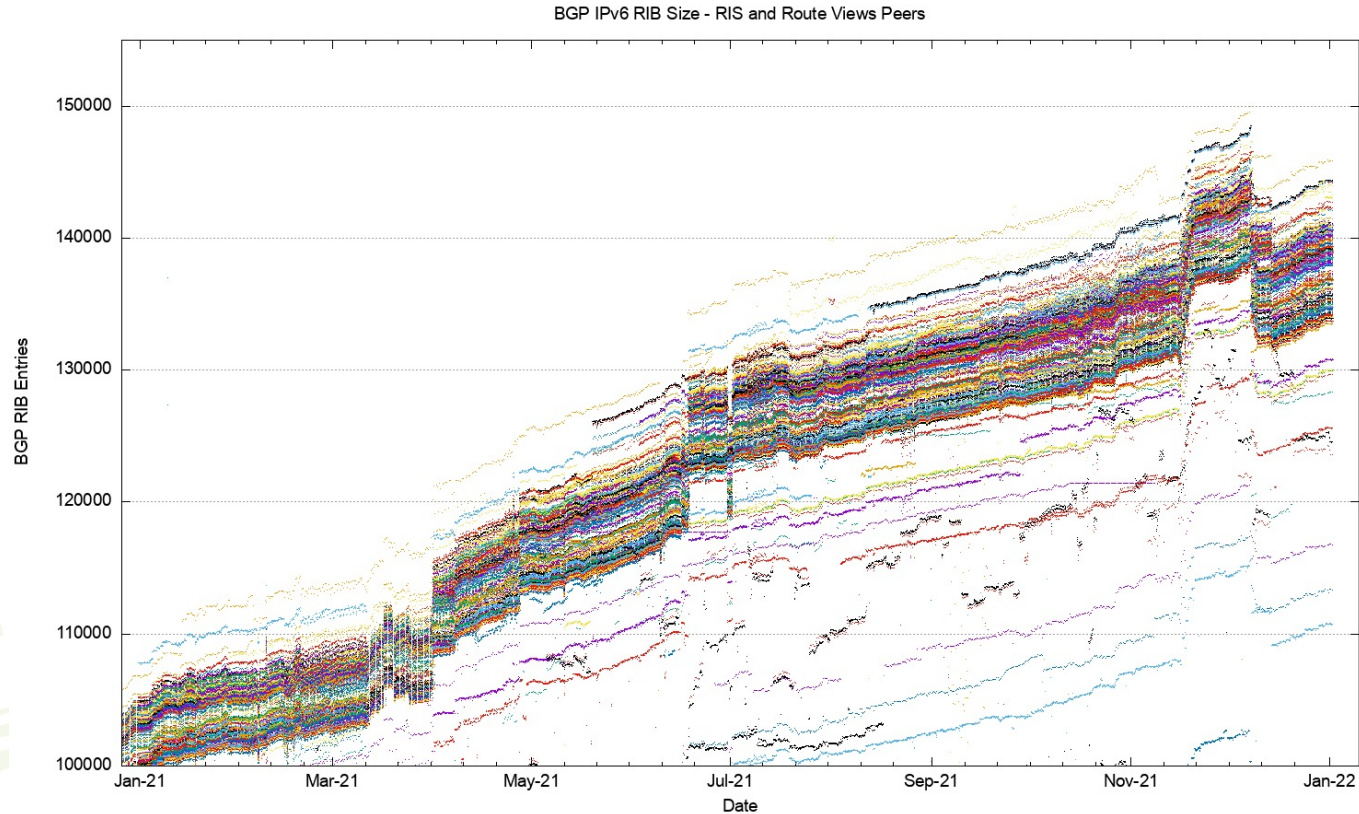
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The Route-Views View of IPv6

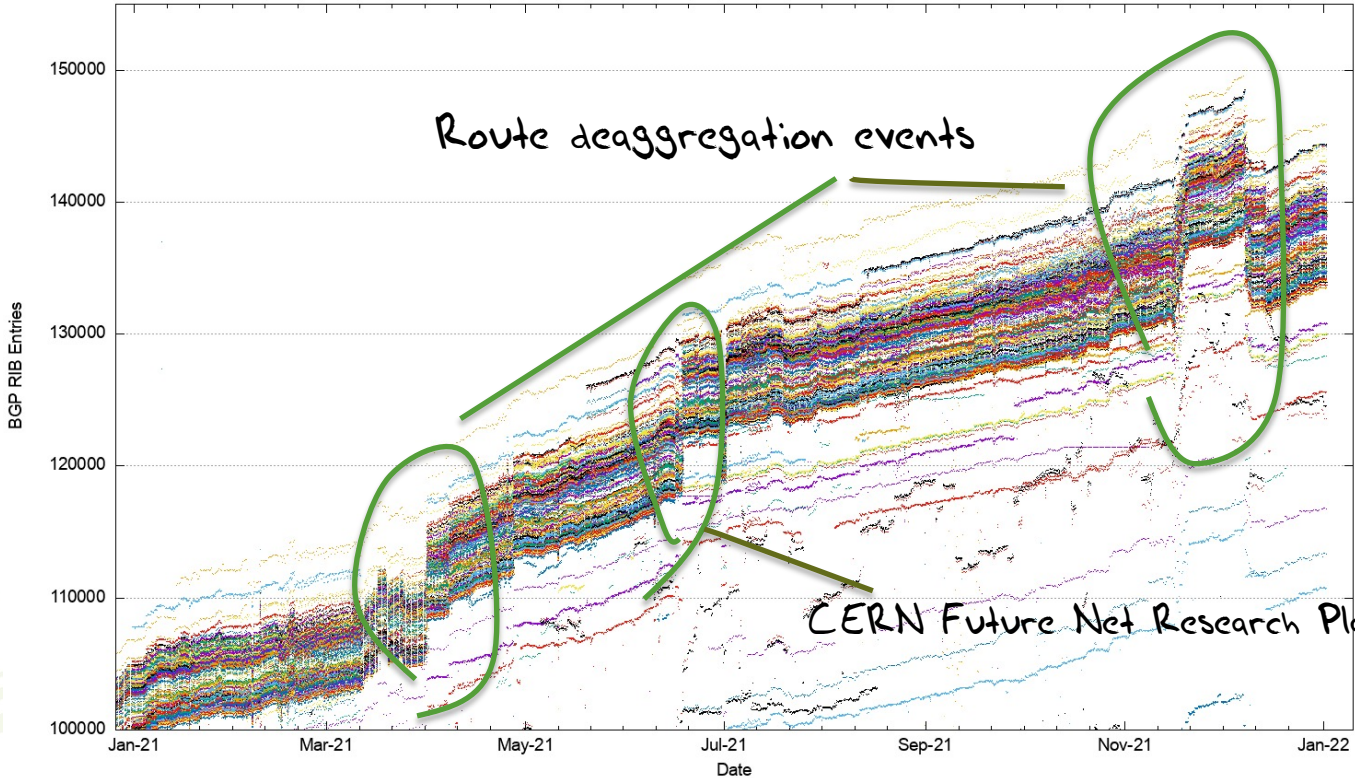


2021 in Detail



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BGP IPv6 RIB Size - RIS and Route Views Peers



V6 in 2021

- Overall IPv6 Internet growth in terms of BGP is still increasing, and is currently at some **41,000 route entries p.a.**
 - With a couple of deaggregation leaks along the way!
- It's a case of increasing growth, not just constant growth
 - More use of /48 more specifics
 - More networks advertising IPv6 prefixes



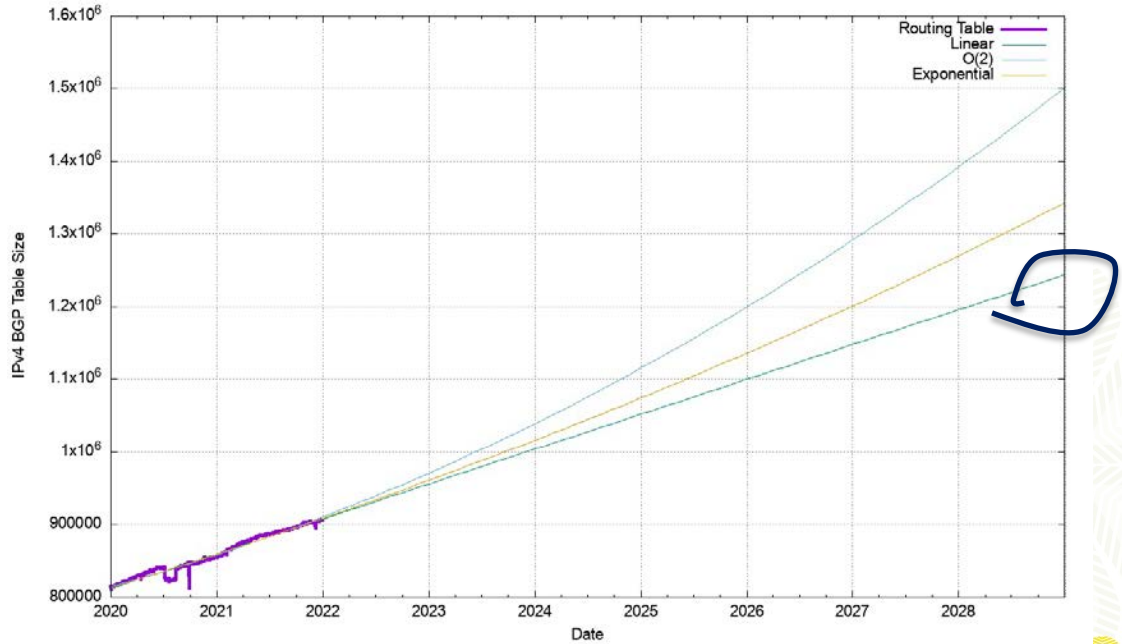
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V4 BGP Table Size Predictions

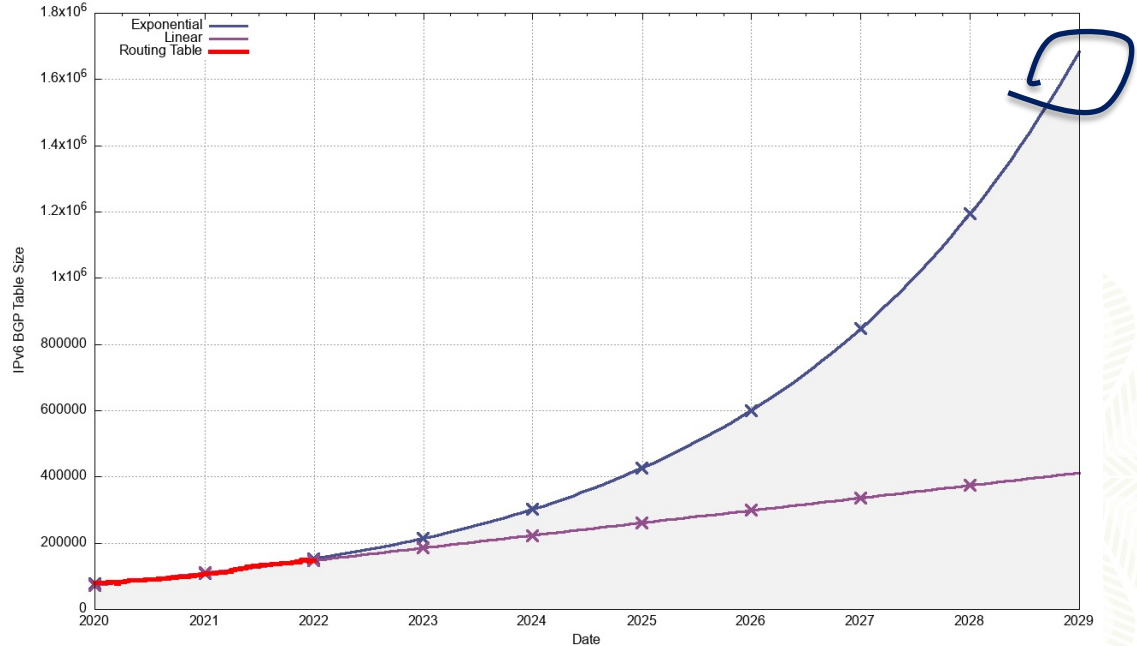
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V6 BGP Table Size Predictions

Linear Exponential

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BGP Table Growth

The absolute size of the IPv6 routing table is growing much faster than the IPv4 table

These two tables will require the same storage/lookup size in around 2 years time, given that each IPv6 entry is 4 times the bit size of an IPv4 entry

The good news ...

As long as we are prepared to live within the technical constraints of the current routing paradigm, the Internet's use of BGP will continue to be viable for some time yet



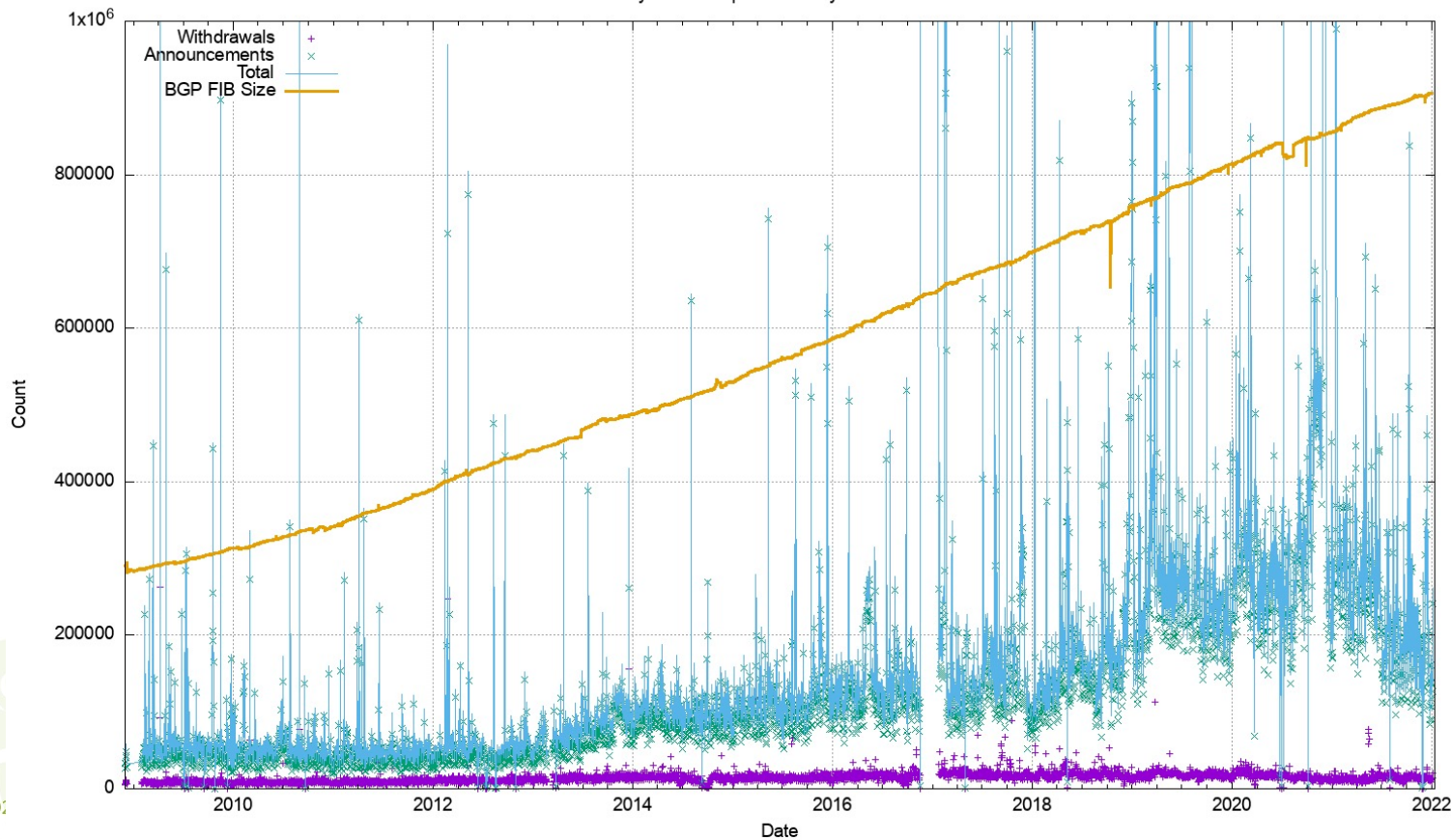
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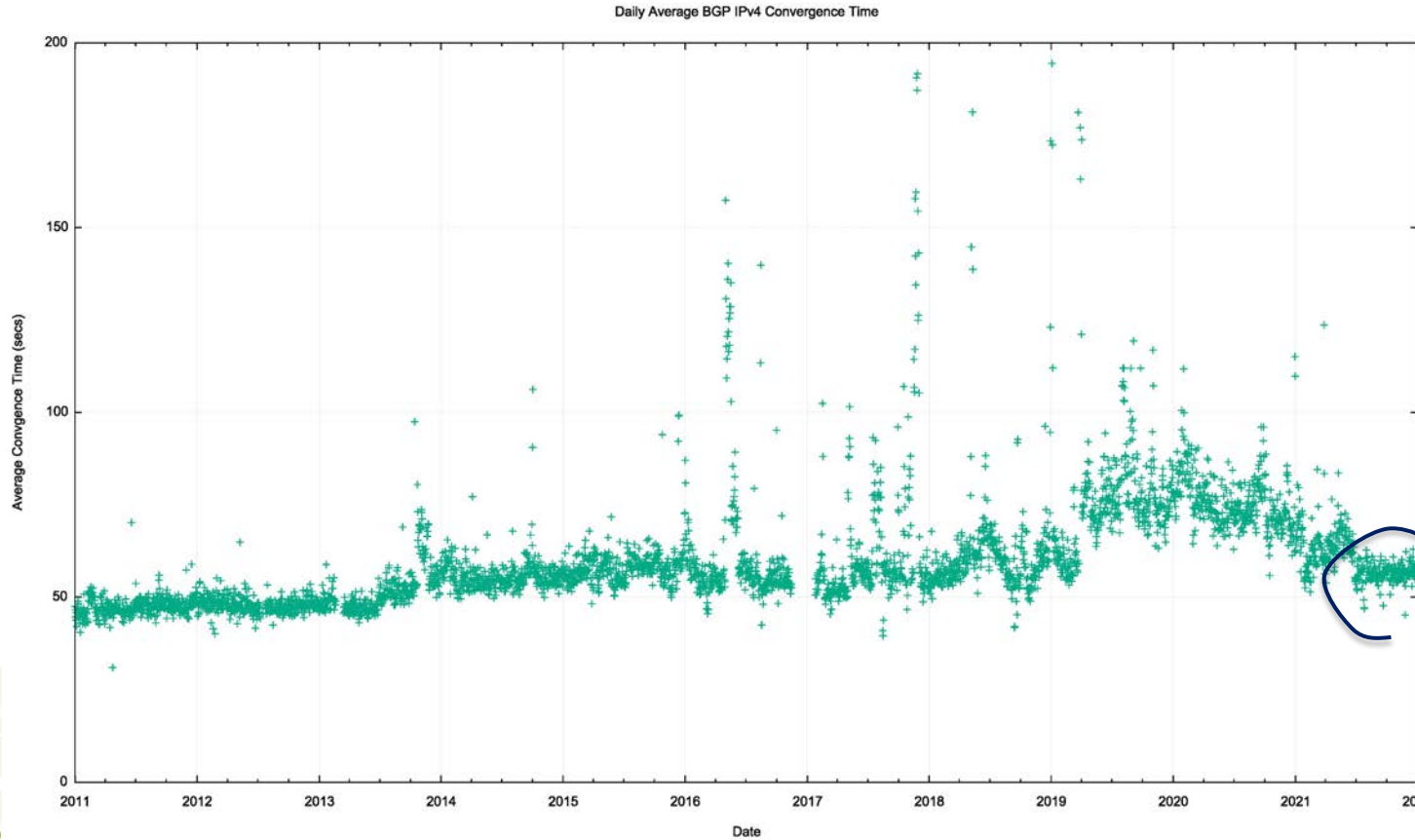


IPv4 BGP Updates

Daily BGP v4 Update Activity for AS131072



IPv4 BGP Convergence Performance



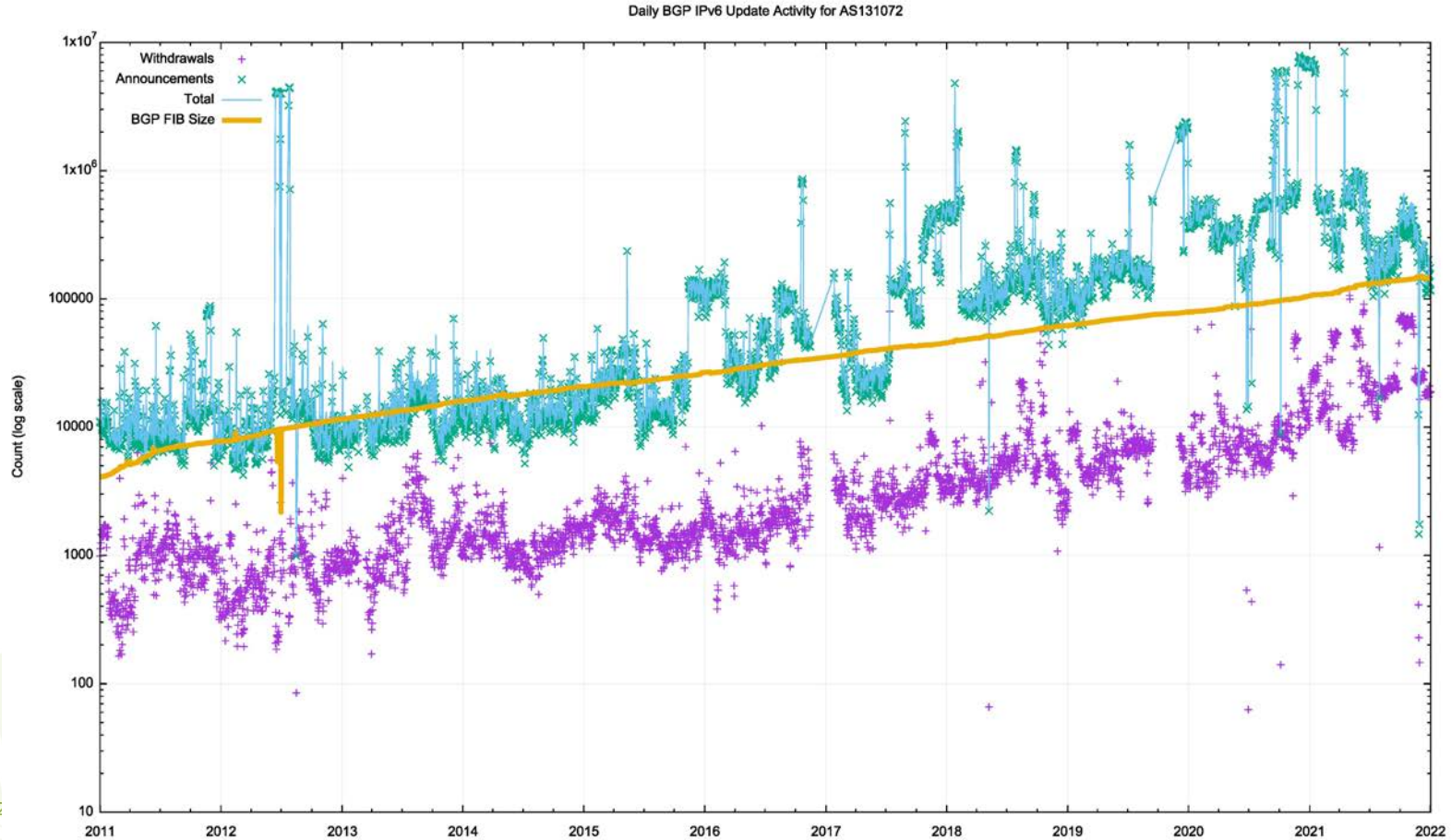
Updates in IPv4 BGP

The IPv4 inter-domain routing system is still highly stable ...

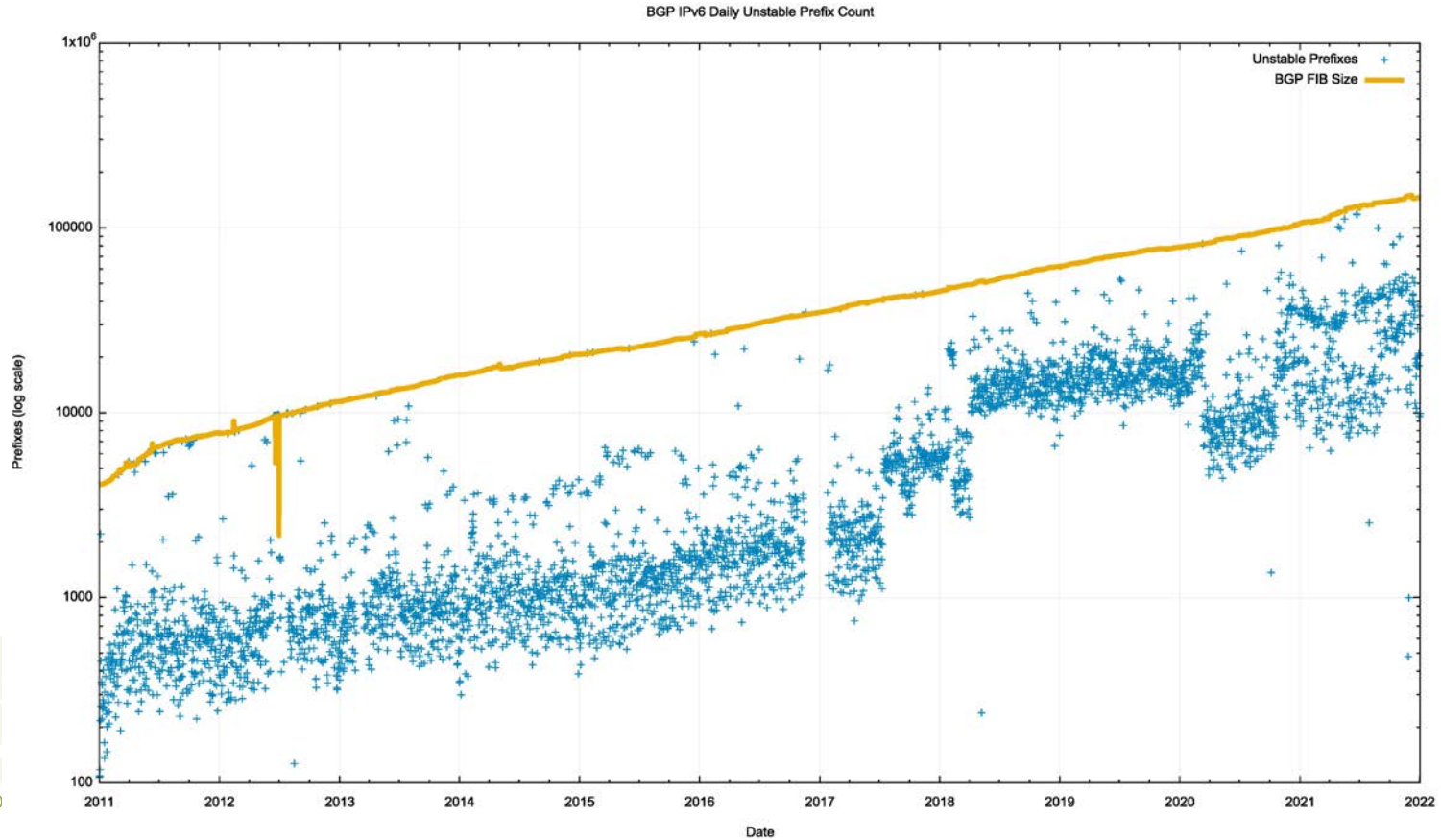
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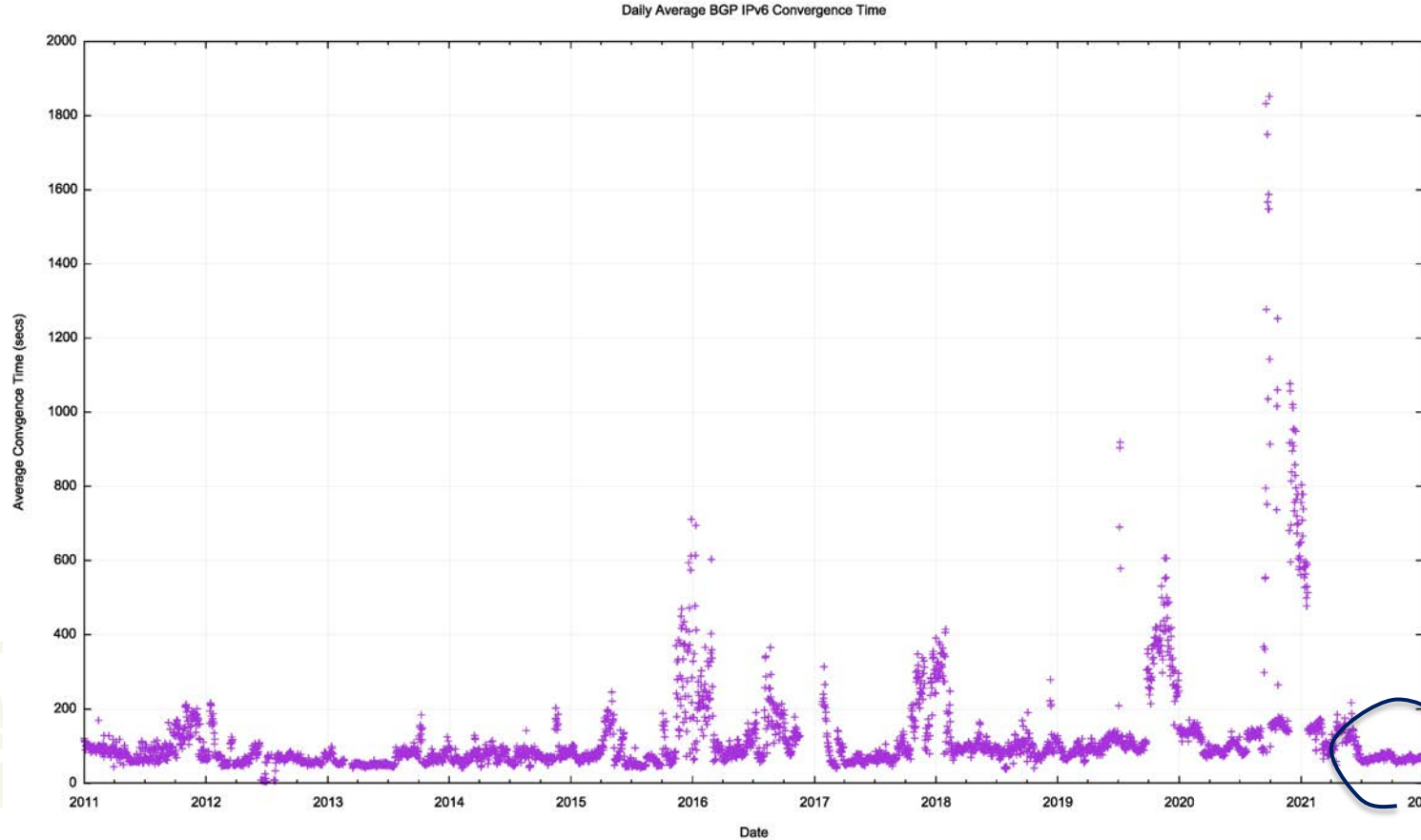
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V6 Unstable Prefixes



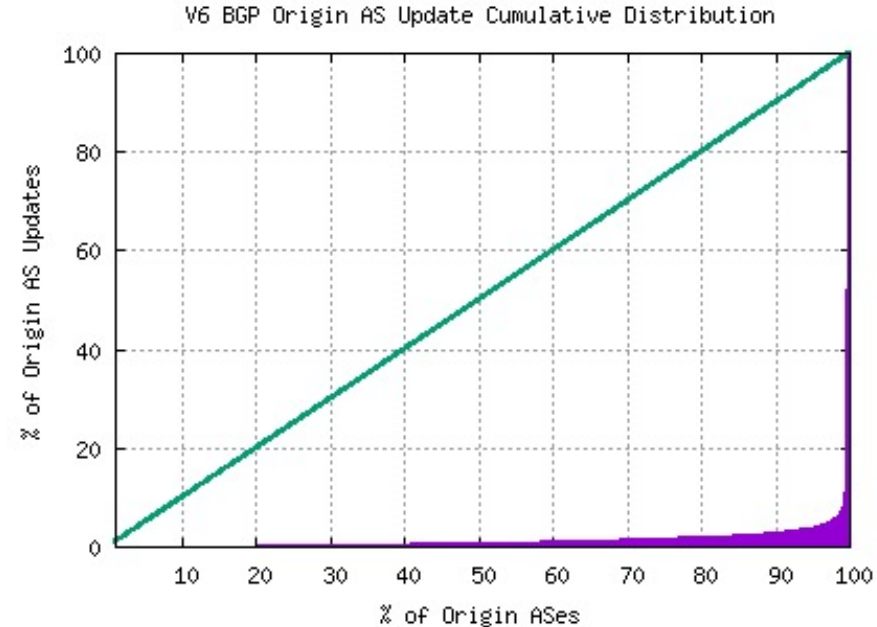
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Updates in IPv6 BGP

It's improving ...

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- Just 2 AS's generated 70% of the BGP update load in the last 2 weeks of 2021. Instability is still concentrated in a small number of pathological cases.



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Routing Futures

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Some Practical Suggestions

Know your network's limits

- Understand your routing hardware's line card FIB capacity in the default-free parts of your network



Some Practical Suggestions

Know your network's limits

Review your routers' settings

- Review your IPv4 / IPv6 portioning in the FIB tables - a dual-stack eBGP router will need 1M 32-bit IPv4 slots and 233K 128-bit IPv6 slots for a full eBGP routing table in line cards in 2 years time if they are using a full eBGP FIB load (plus internal routes of course). That's the same memory footprint for IPv4 and IPv6!



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Default routes can be helpful

- Judicious use of **default** routes in your internal network may allow you drop this requirement significantly



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Time for hot caching in line card FIBs?

- Using a hot cache for line card FIB cache would reduce the high-speed TCAM memory requirement significantly without visible performance cost



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That's it!

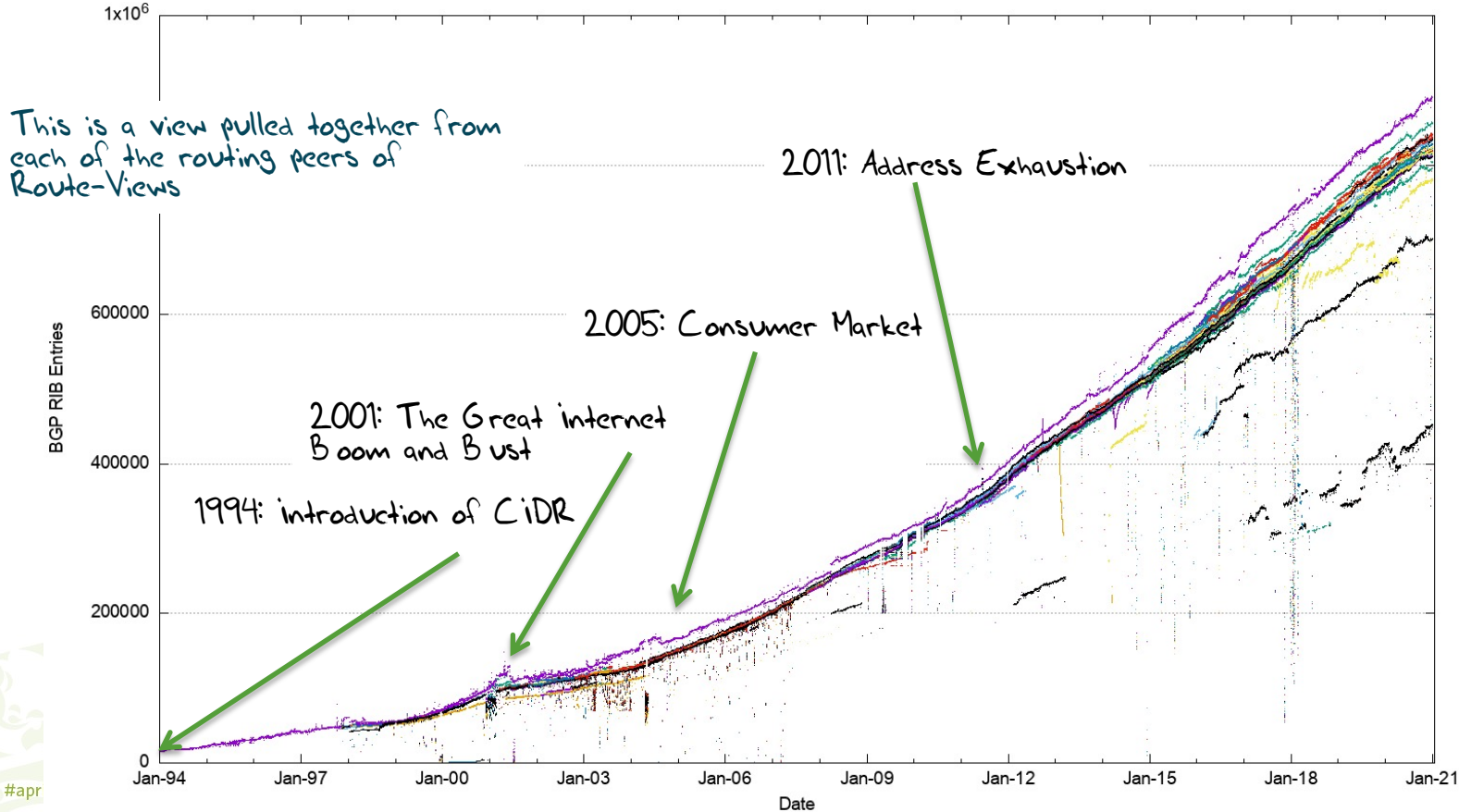
Questions?

The Complete Pack

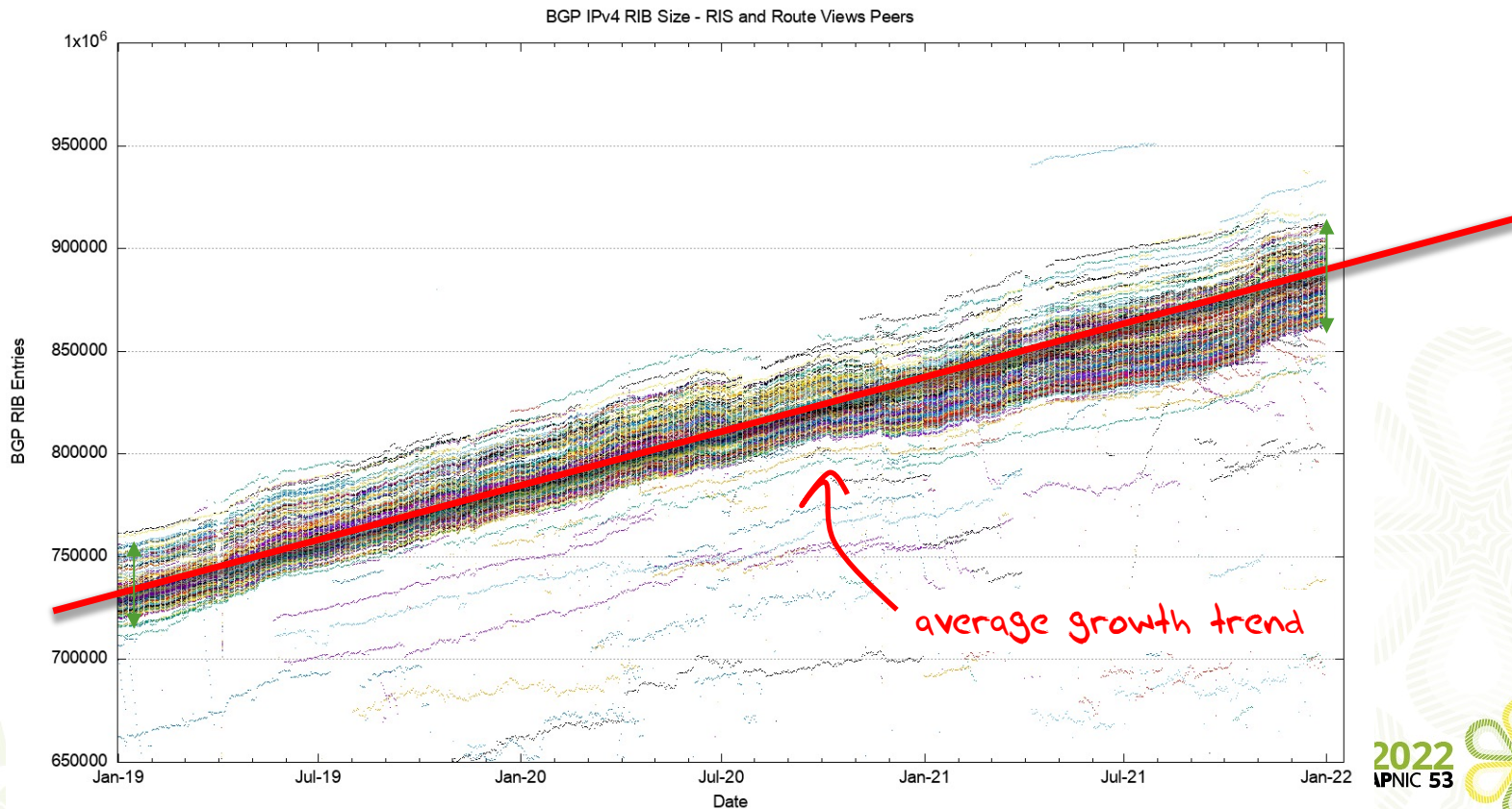


27 Years of Routing the Internet

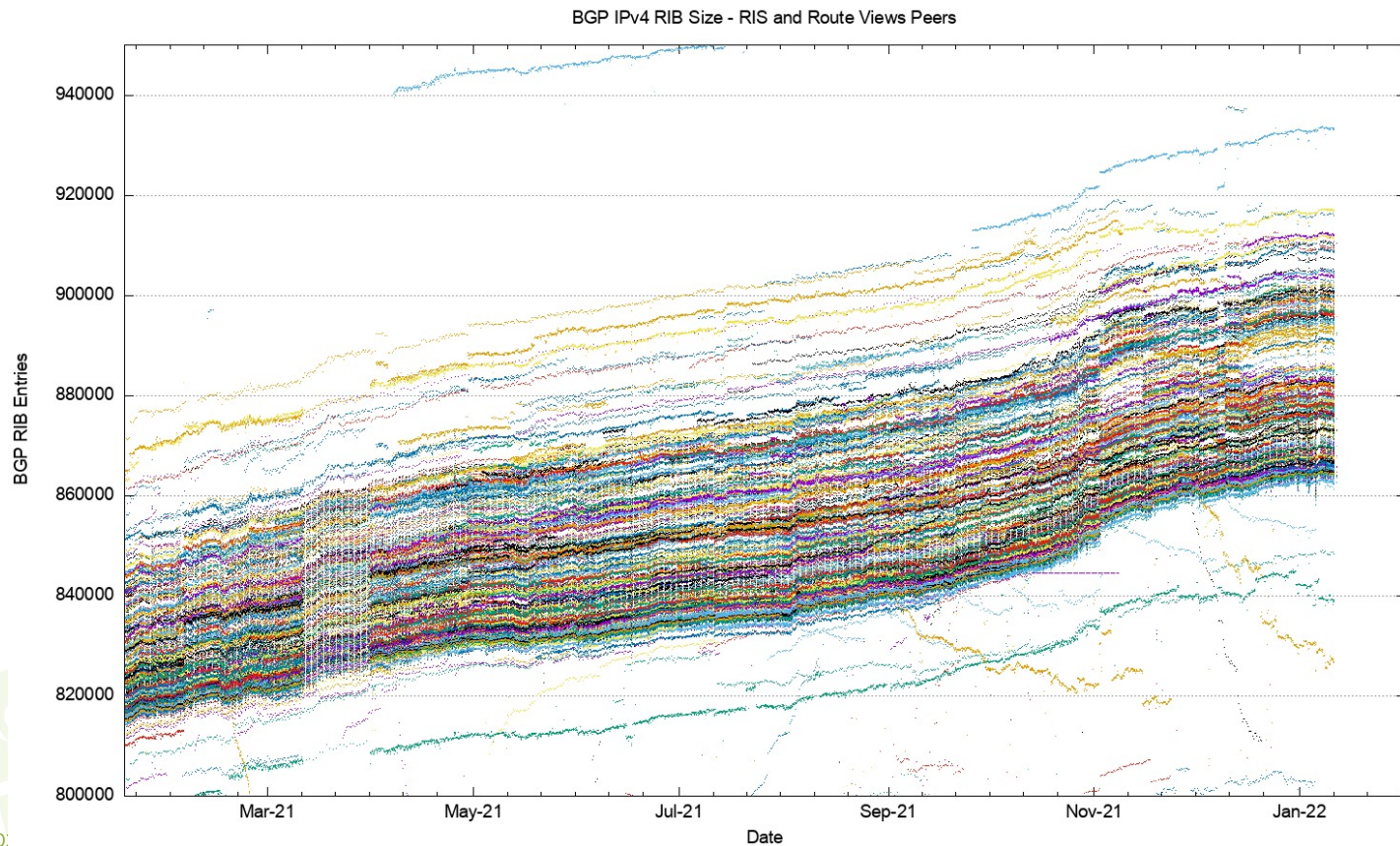
BGP IPv4 RIB Size - Route Views Peers



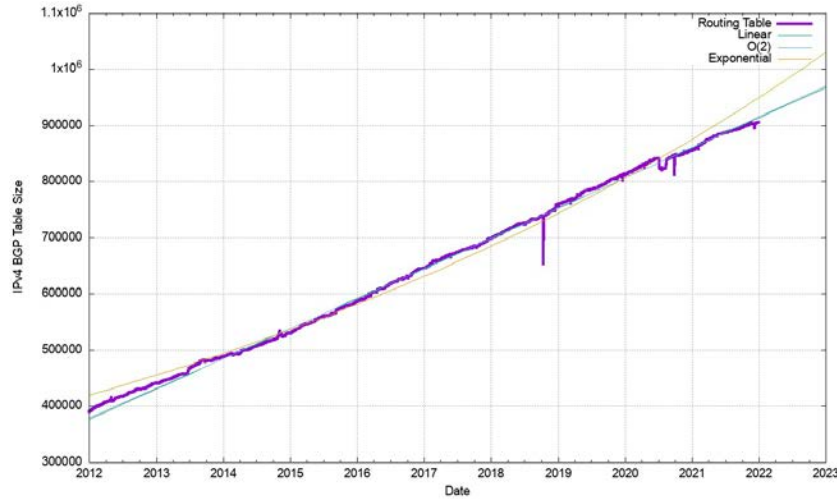
2017-2022 in detail



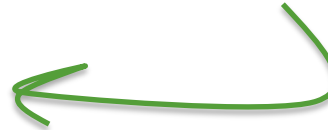
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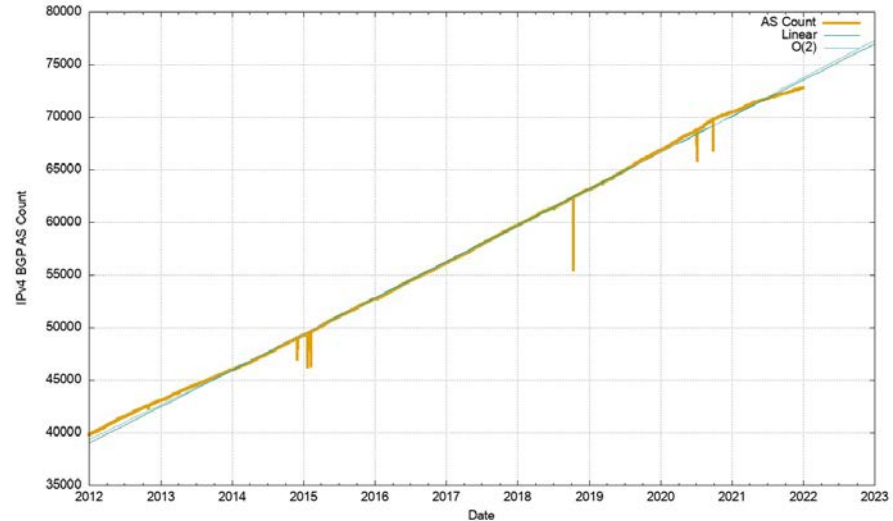
Routing Indicators for IPv4



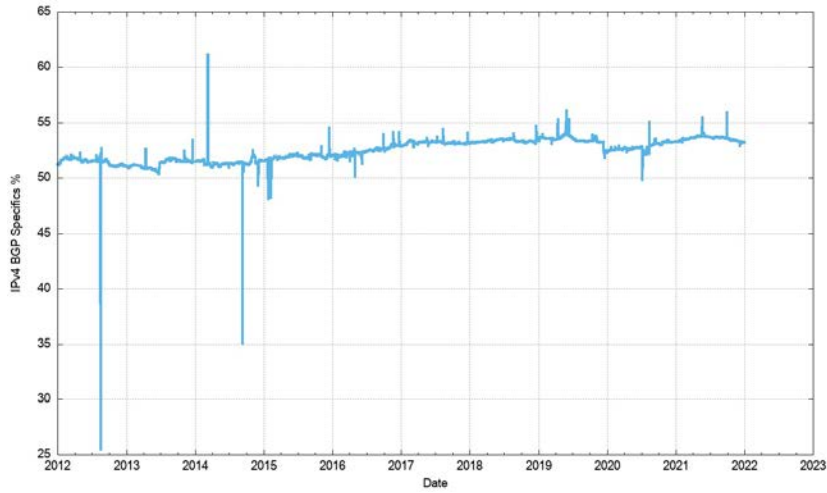
Routing prefixes - growing by some 40,000 prefixes per year



AS Numbers - growing by some 2,400 prefixes per year



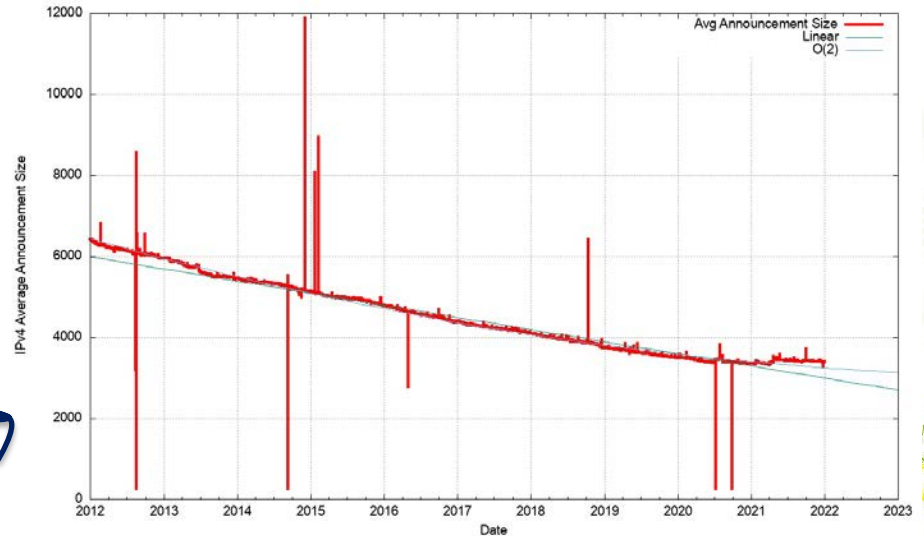
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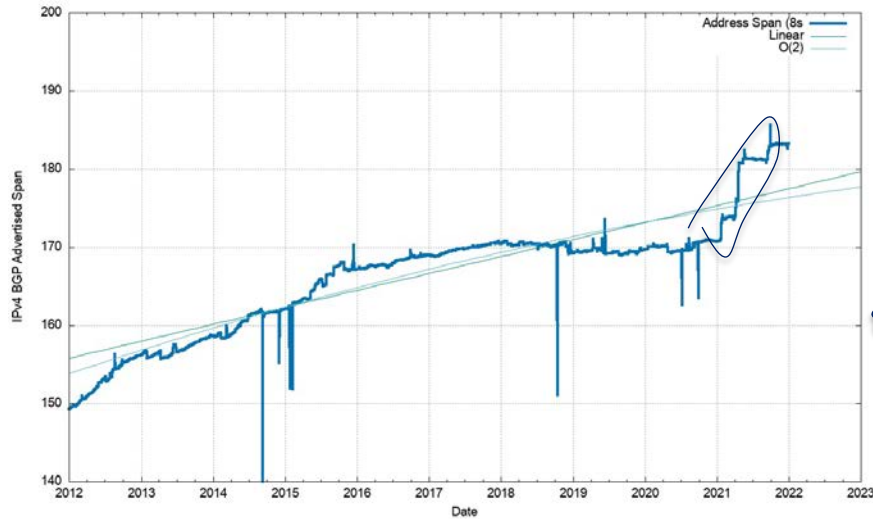
More Specifics are still taking up slightly more than one half of the routing table



But the average size of an IPv4 routing advertisement continues to shrink

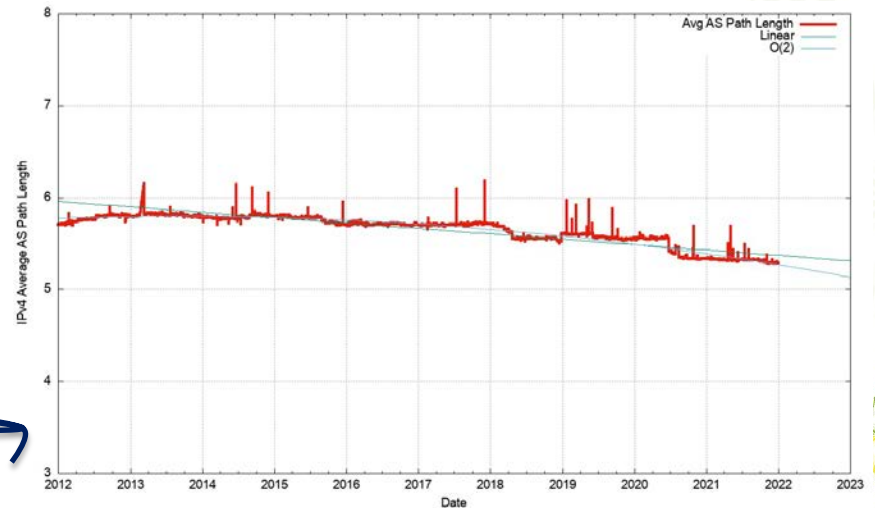


Routing Indicators for IPv4



The US DoD advertised its collection of legacy 18 prefixes in 2021

The “shape” of inter-AS interconnection appears to be trending to a more compact topology



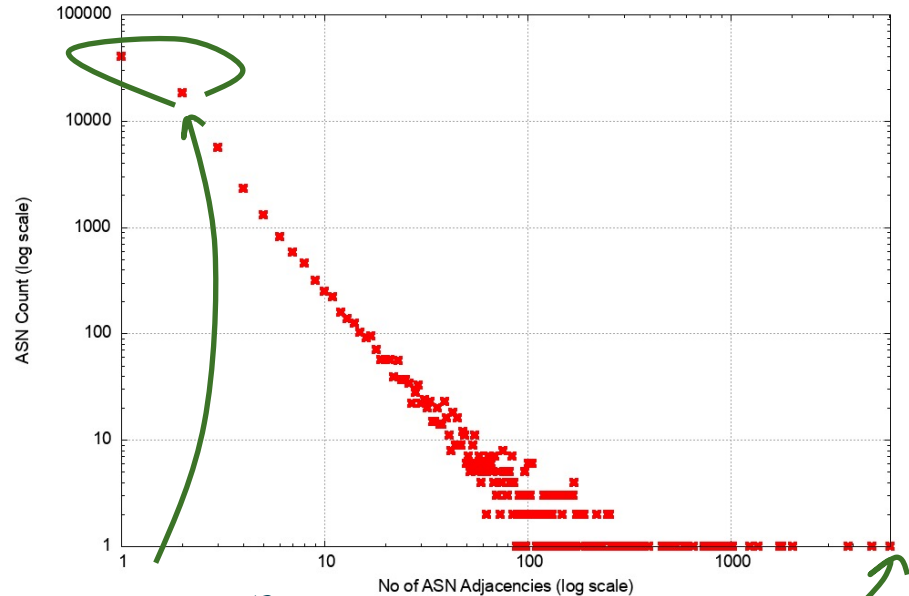
AS Adjacencies (as seen by AS131072)

59,044 out of 72,930 ASNs have 1 or 2 AS Adjacencies (82%)

2,425 ASNs have 10 or more adjacencies

9 ASNs have >1,000 adjacencies

6,059	AS6939	HURRICANE - Hurricane Electric, Inc., US
4,977	AS3356	LEVEL3 - Level 3 Communications, Inc., US
3,743	AS174	COGENT-174 - Cogent Communications, US
2,015	AS6461	ZAYO Bandwidth, US
1,776	AS3257	GTT-Backbone, DE
1,742	AS7018	ATT-INTERNET4 - AT&T Services, Inc., US
1,372	AS1299	TWELVE99 Arelion (fka Telia Carrier), SE
1,243	AS2914	NTT America, US
1,023	AS12389	ROSTELECOM, RU



Most networks are stub AS's

A small number of major connectors



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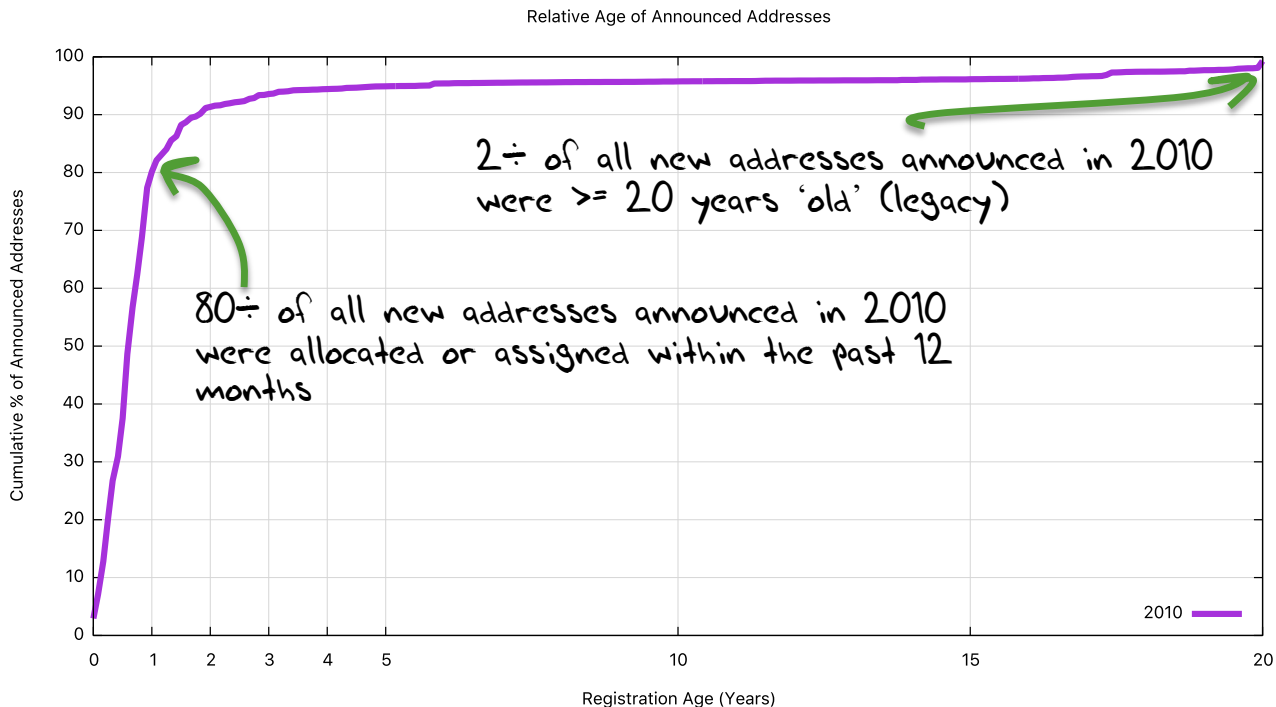
Post-Exhaustion Routing Growth

- What's driving this post-exhaustion growth?
 - Transfers?
 - Last /8 policies in RIPE and APNIC?
 - Leasing and address recovery?



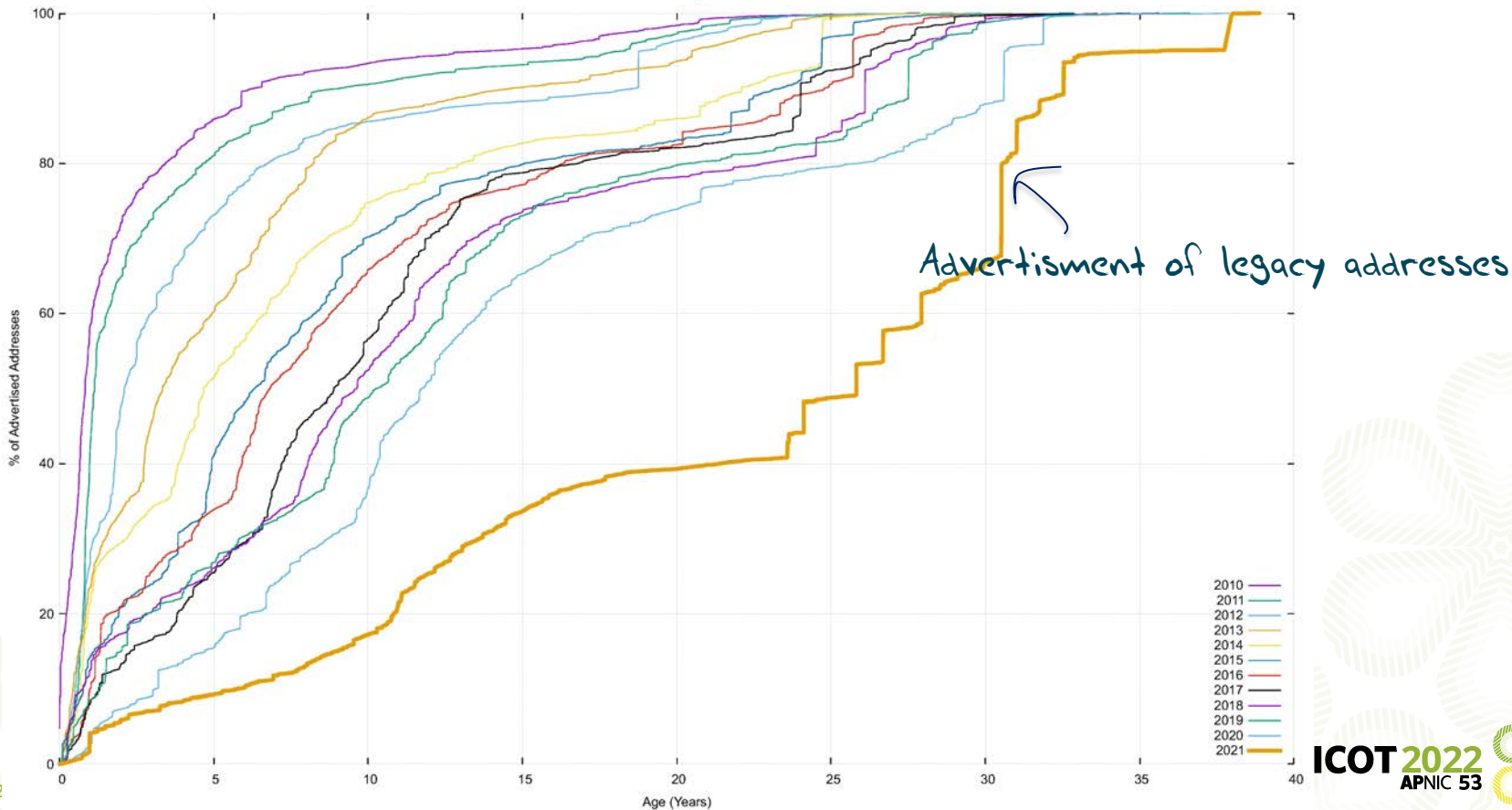
Advertised Address "Age"

2010

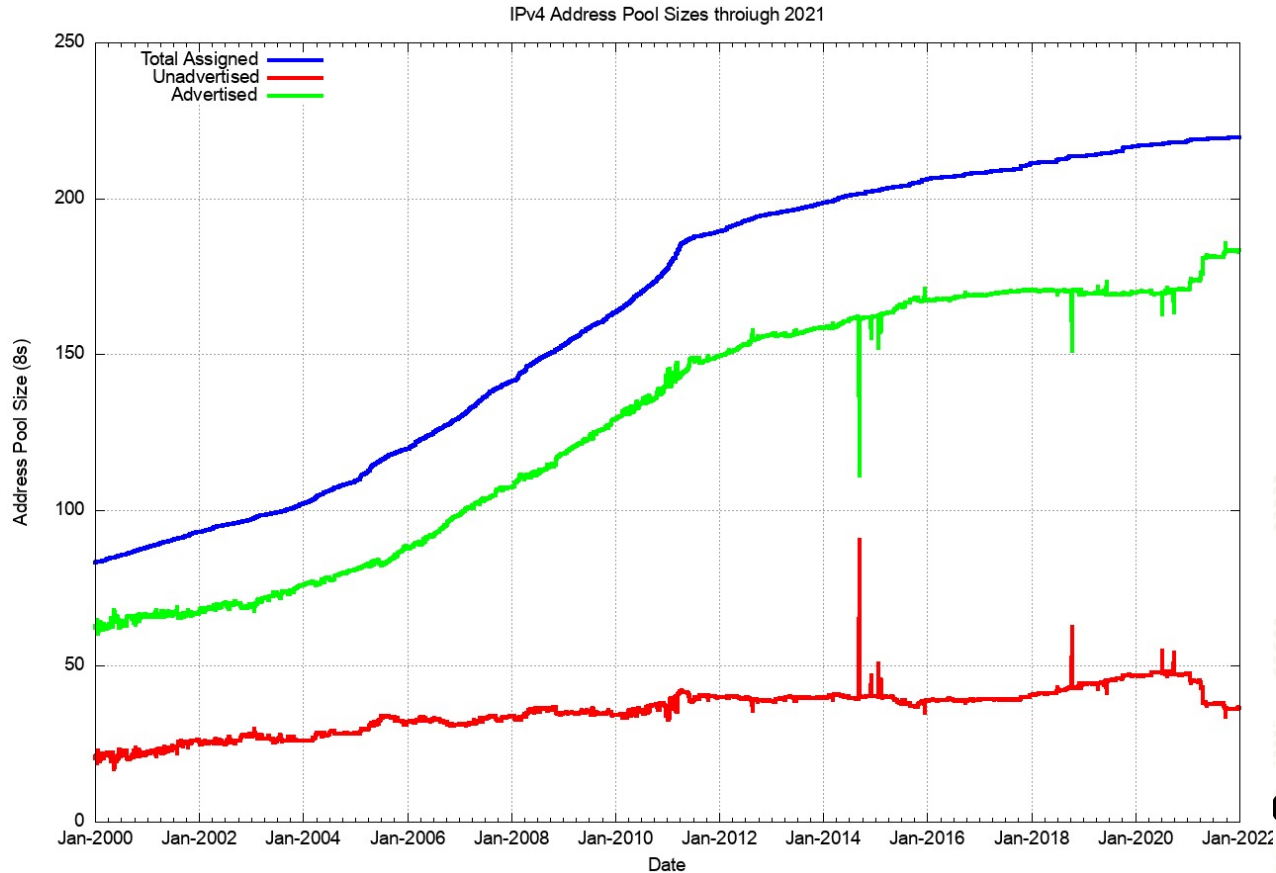


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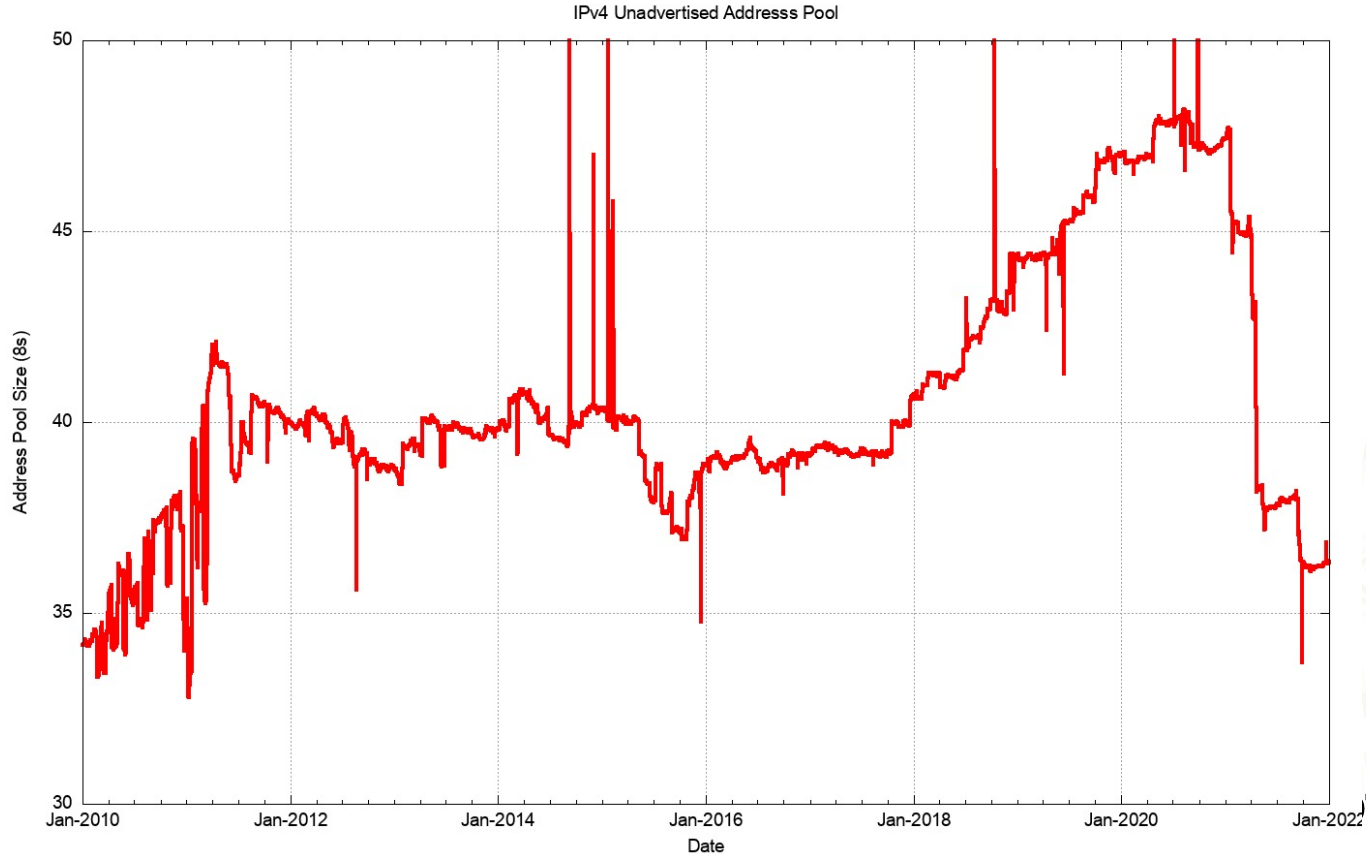
Advertised Address Age Distribution



IPv4 Advertised vs Unadvertised

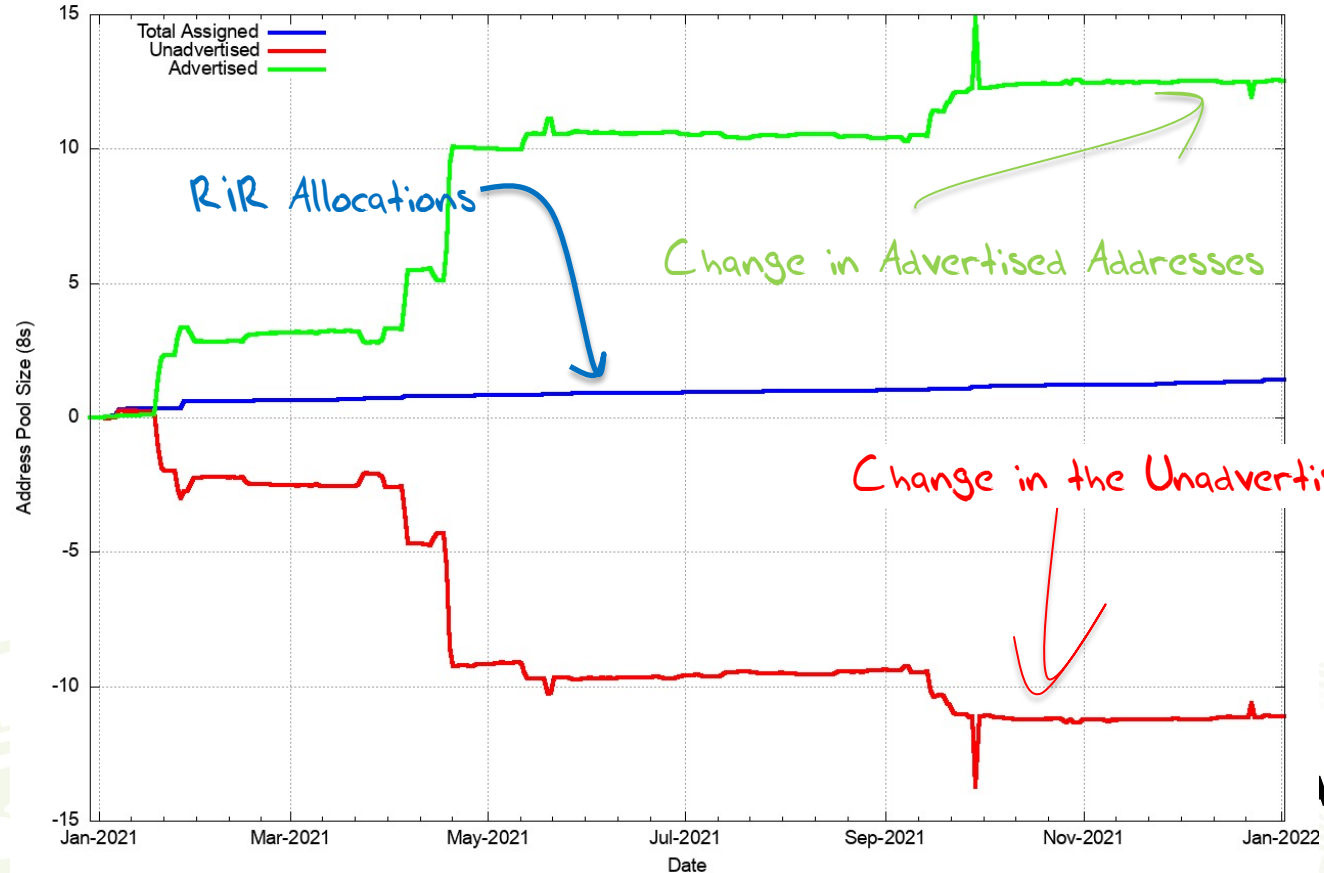


2010 - 2021: Unadvertised Addresses



2021: Assigned vs Recovered

IPv4 Address Pool Sizes through 2021



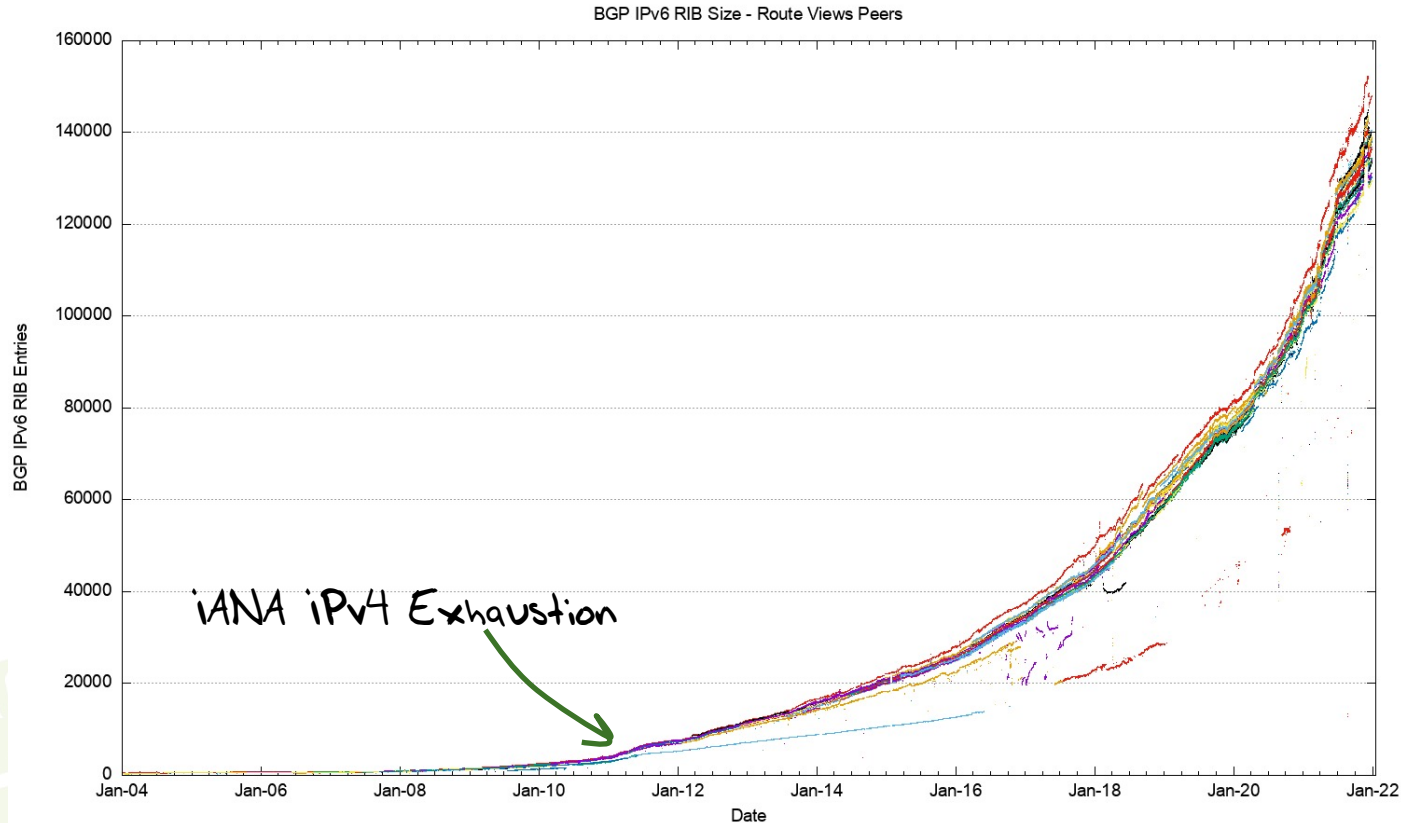
V4 in 2021

- 199.6M addresses were **added** to the routing table across 2020
- 1.1M addresses were **assigned** by RIRs in 2019
- And a net of 198.5M addresses were **drawn** from the pool of unadvertised addresses

The major shift in 2021 was the advertisement of the previously dormant legacy /8s that were assigned to the US DoD in the early days of the ARPANET/Internet

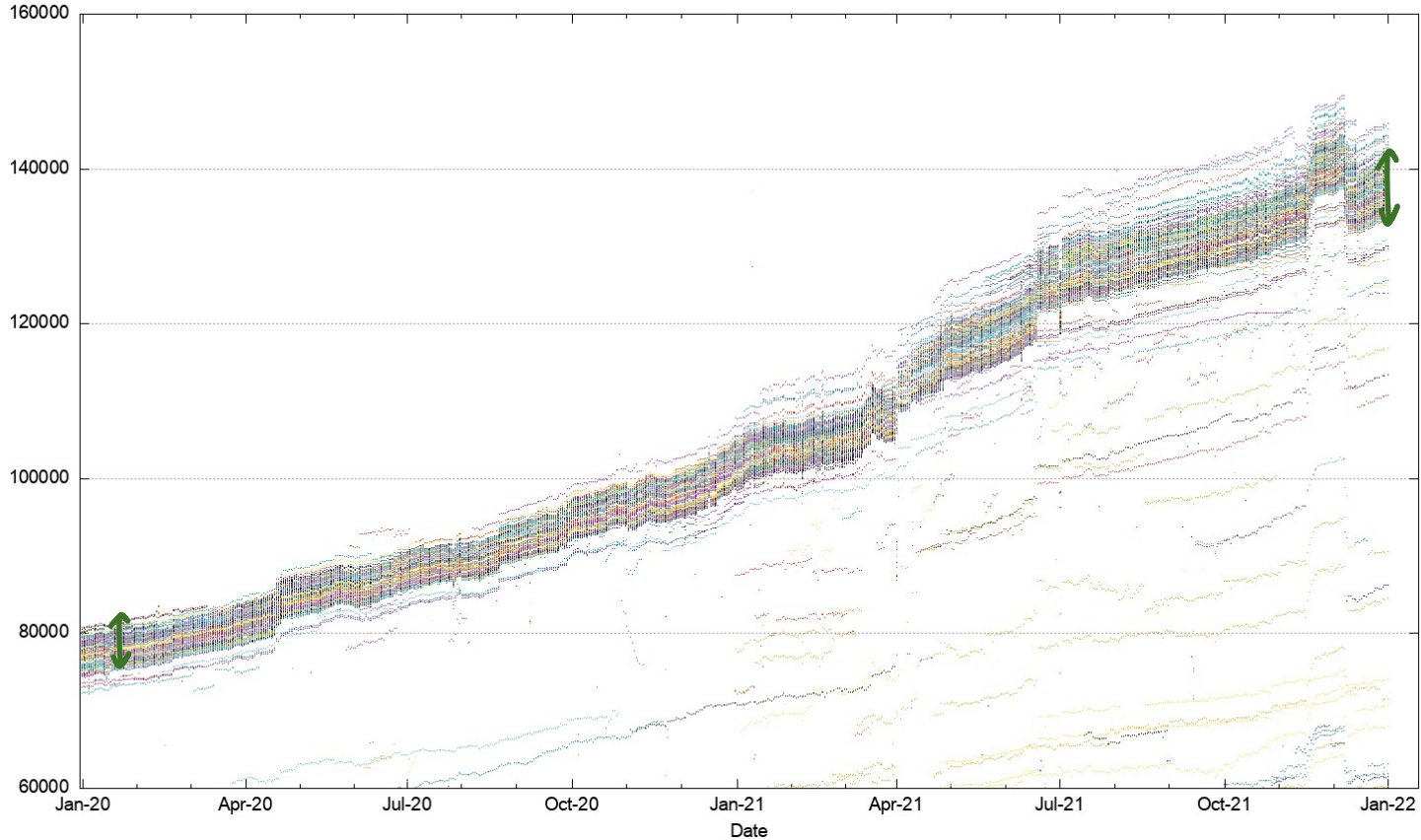


The Route-Views View of IPv6

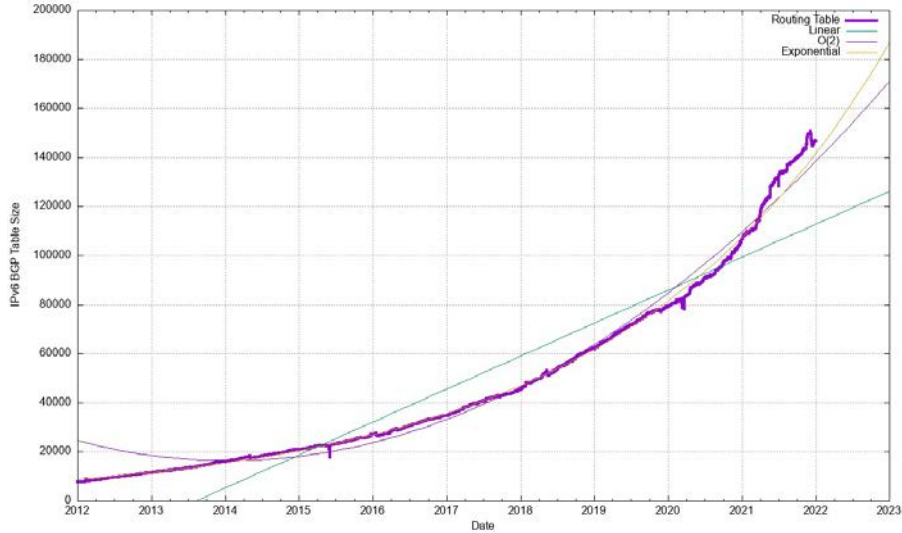


2020-2022 in Detail

BGP IPv6 RIB Size - RIS and Route Views Peers



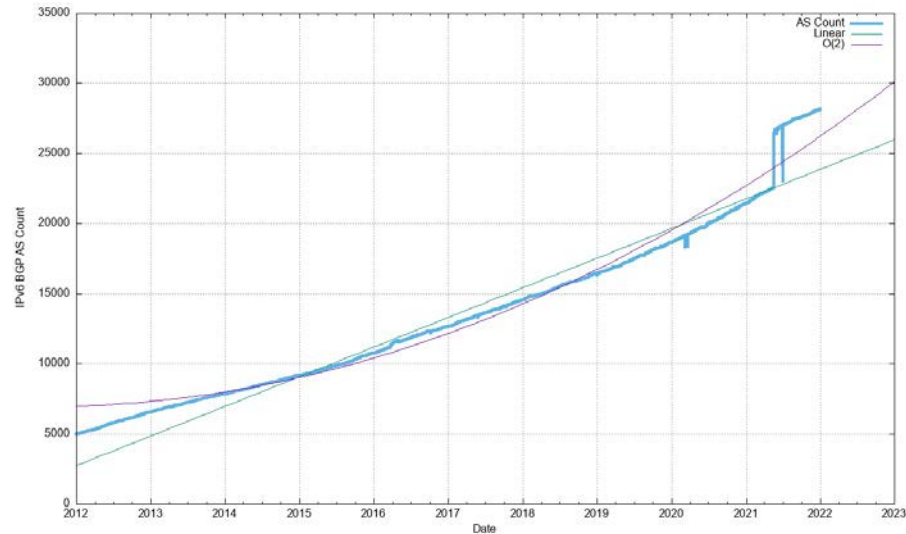
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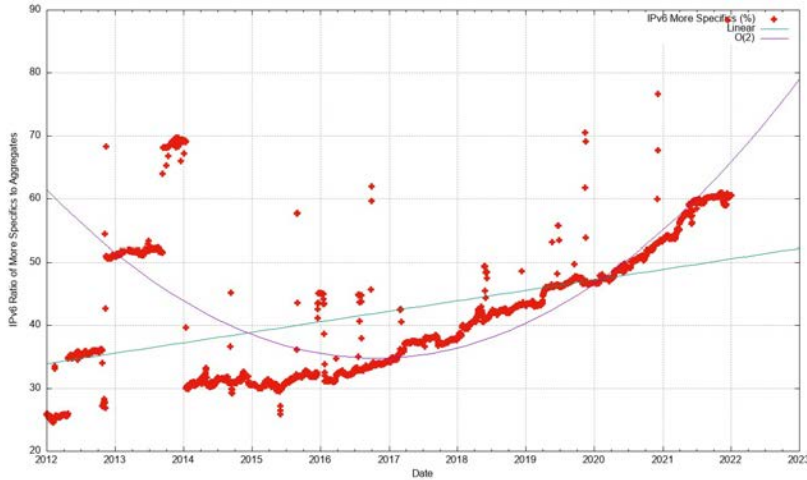
Routing prefixes - growing by some 46,000 prefixes per year



AS Numbers - growing by some 2,400 ASNs per year - with 6,740 added in 2021



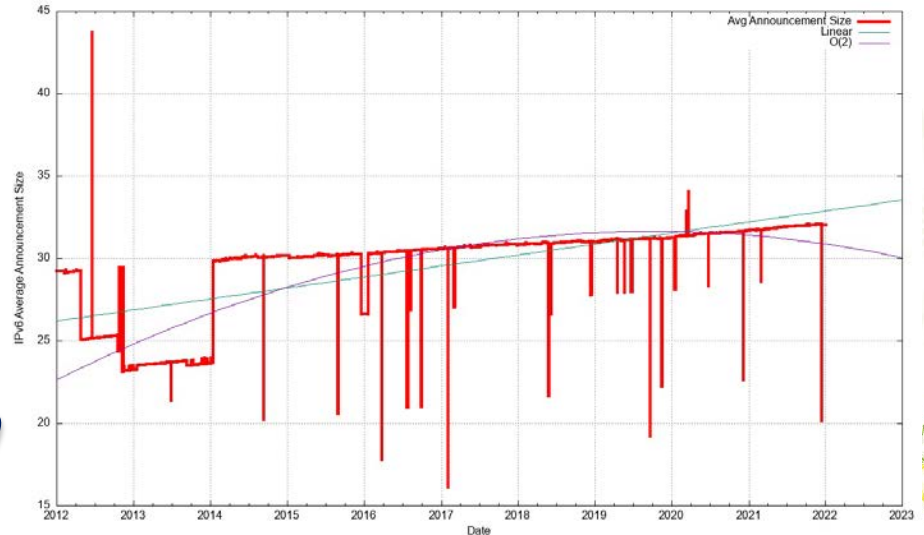
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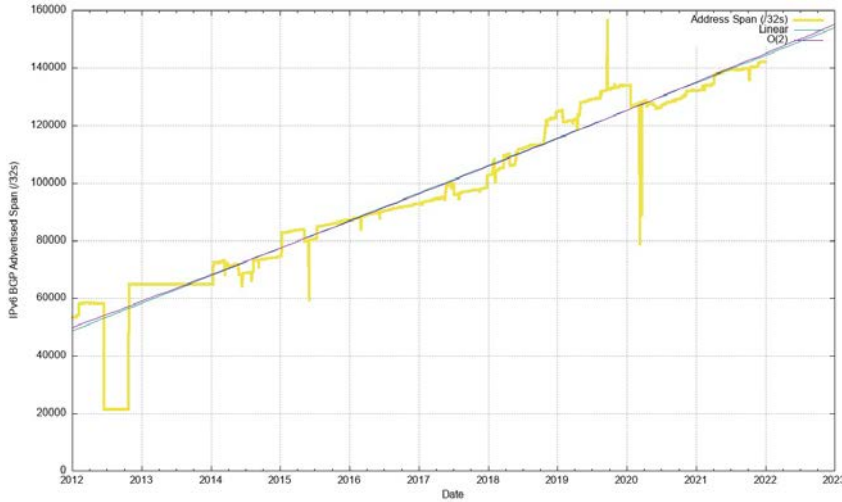
More Specifics now take up 60% of the routing table



The average size of a routing advertisement is getting smaller



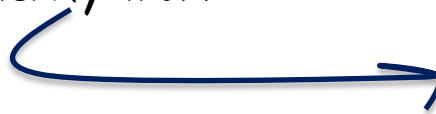
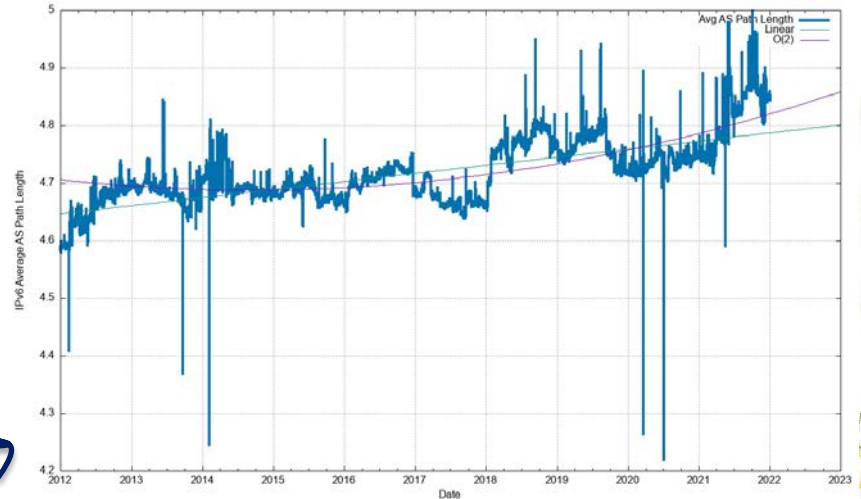
Routing Indicators for IPv6



Advertised Address span is growing at an exponential rate



The “shape” of inter-AS interconnection in IPv6 is rising slightly. Local connections appear to be replacing overlay trunk transits



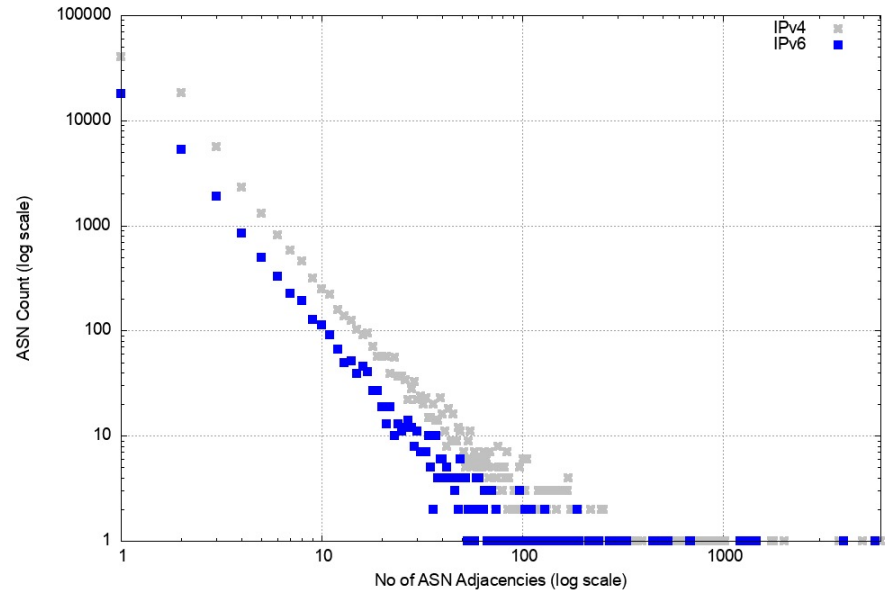
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What to expect



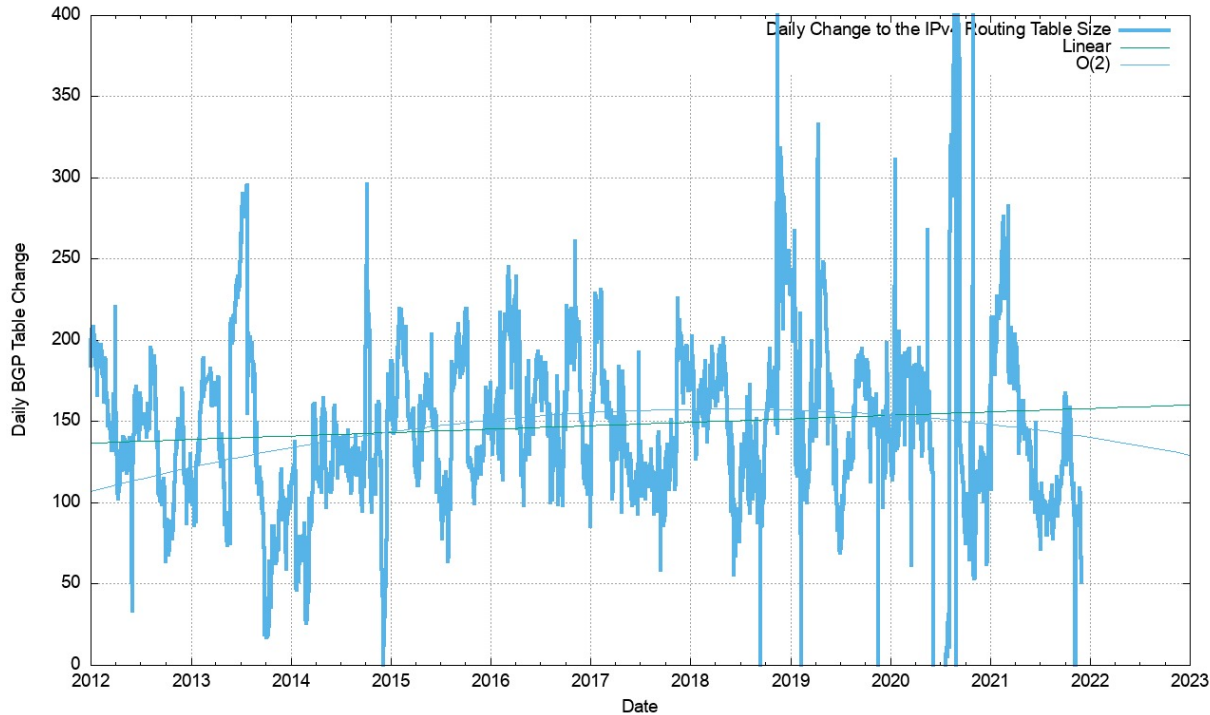
BGP Size Projections

How quickly is the routing space growing?

What are the projections of future BGP FIB size?



V4 - Daily Growth Rates

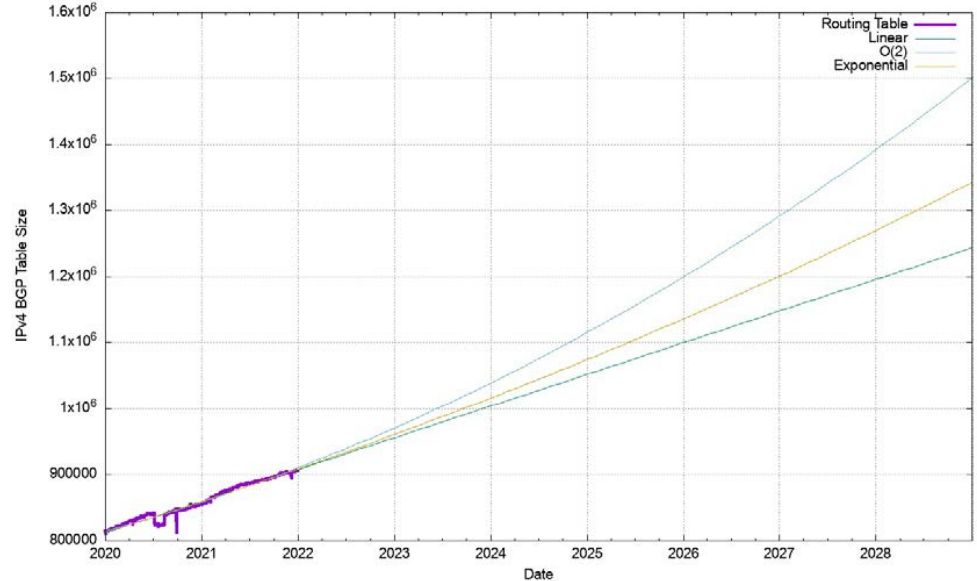


Growth in the V4 network appears to be constant at a long-term average of 150 additional routes per day, or some 54,000 additional routes per year. Recent growth rates are lower

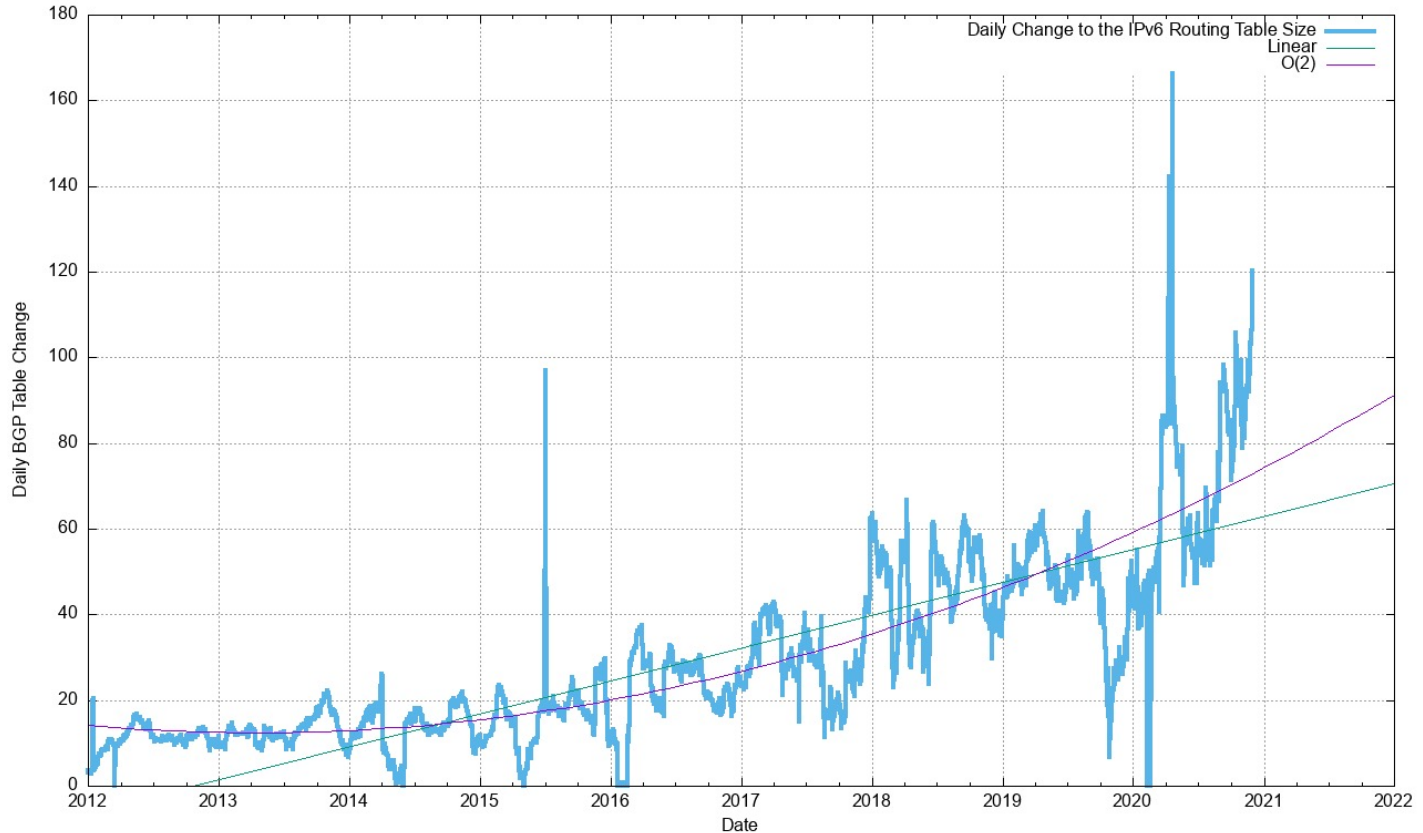
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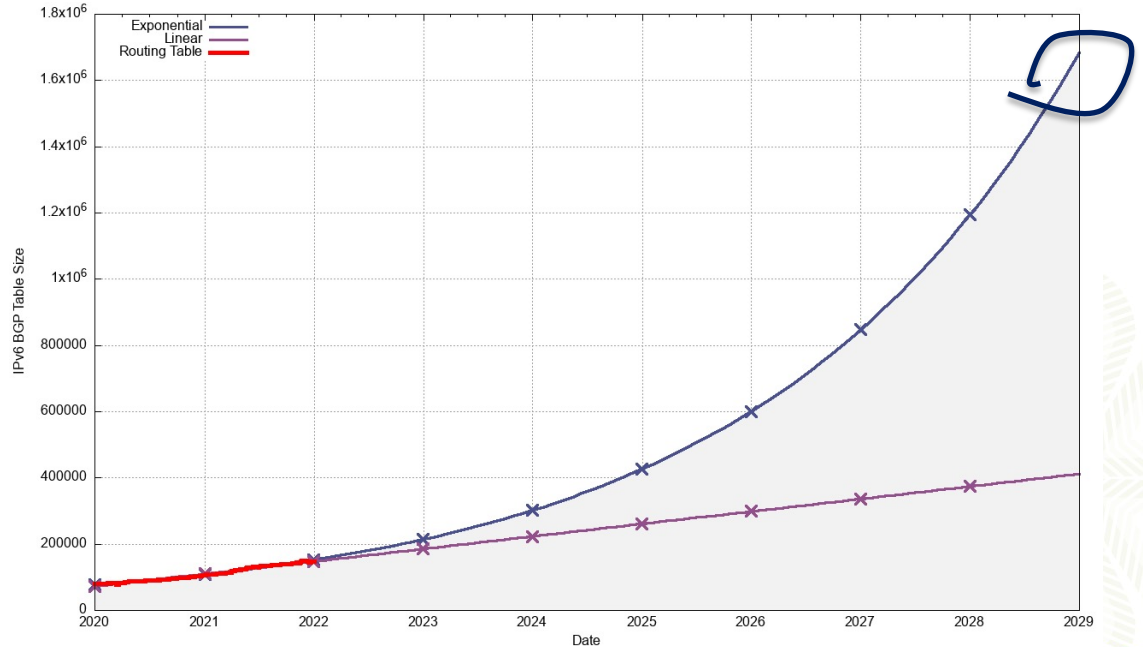
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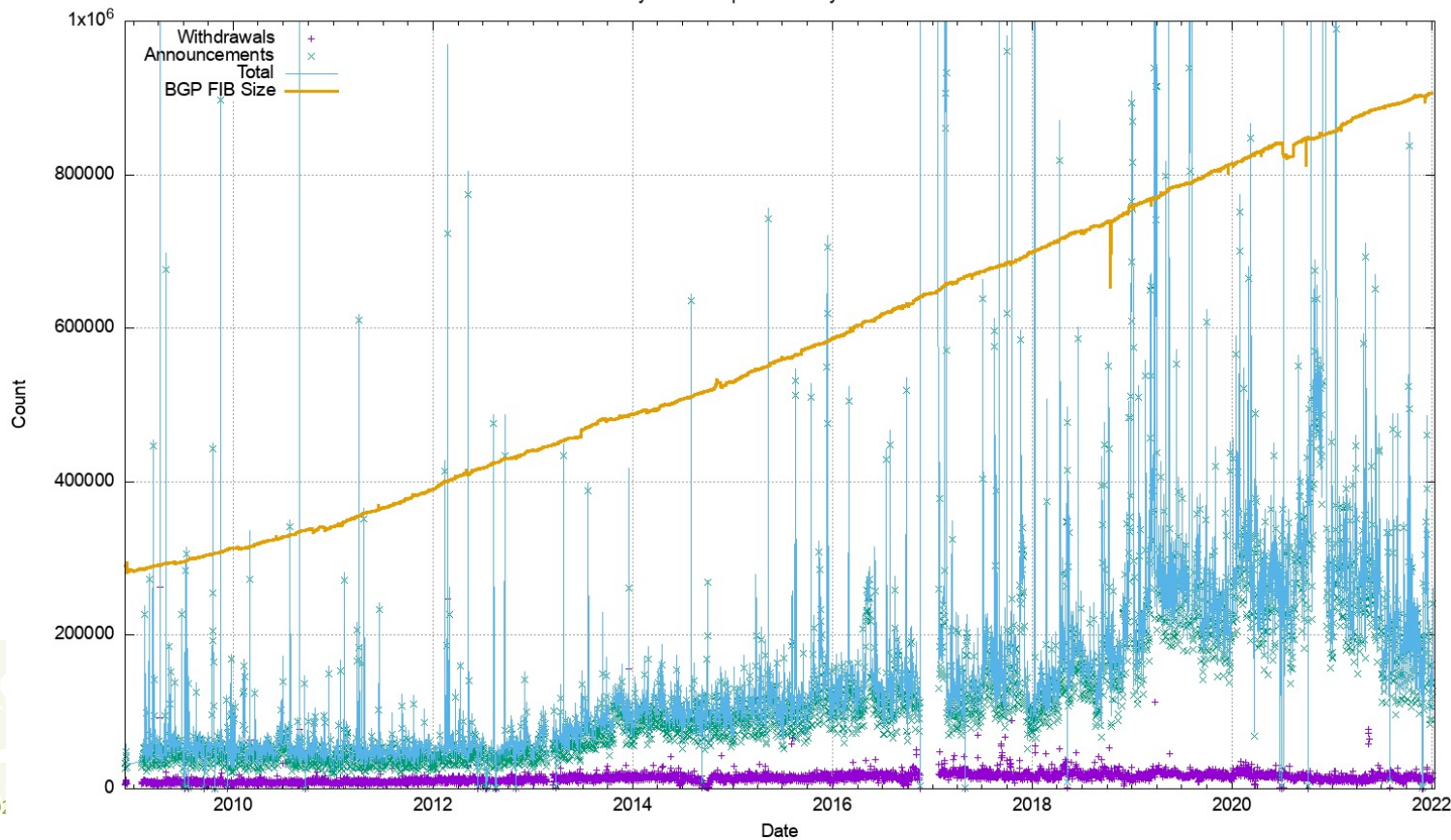
BGP Updates

- What about the rate of updates in BGP?

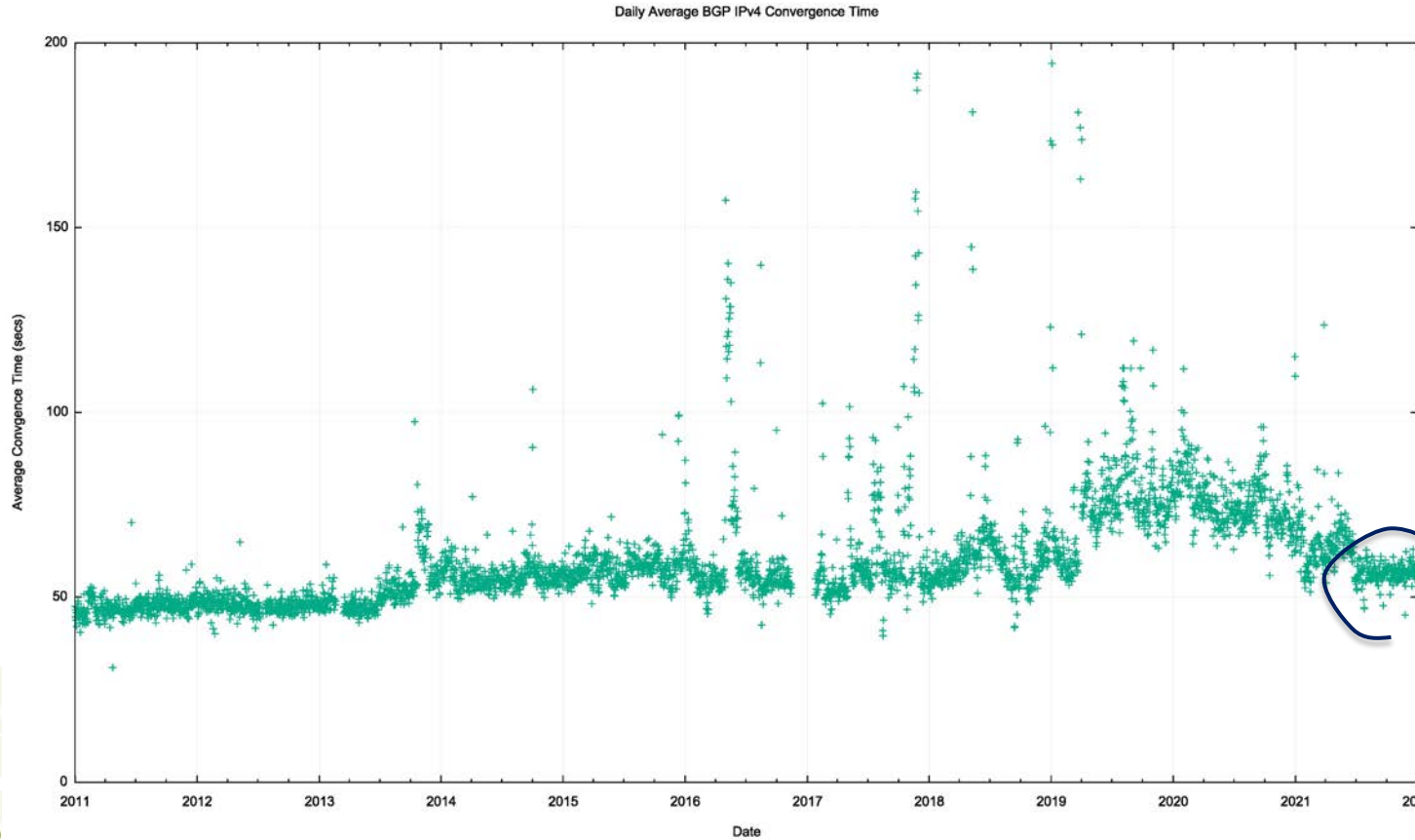


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IPv4 BGP Convergence Performance



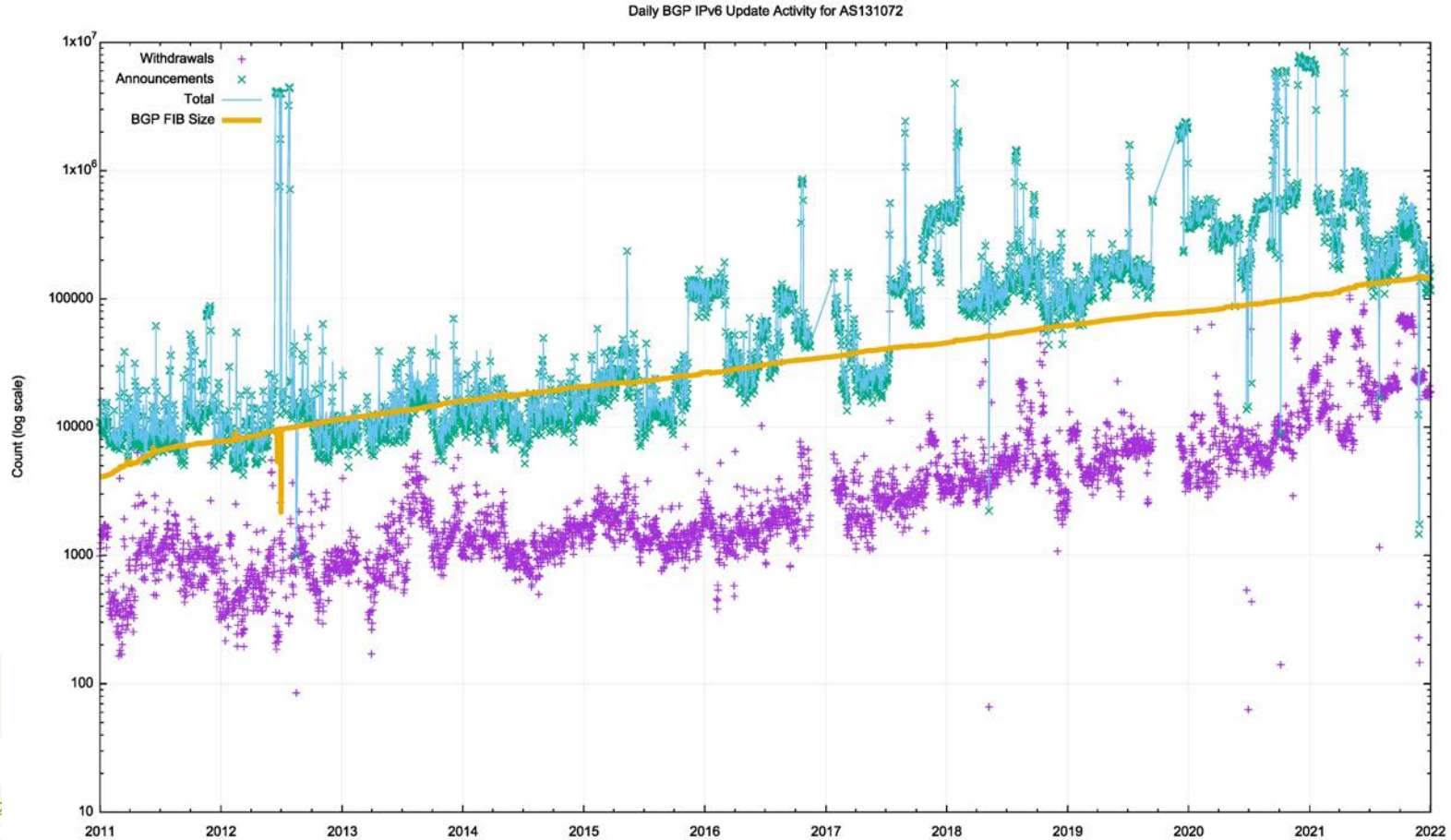
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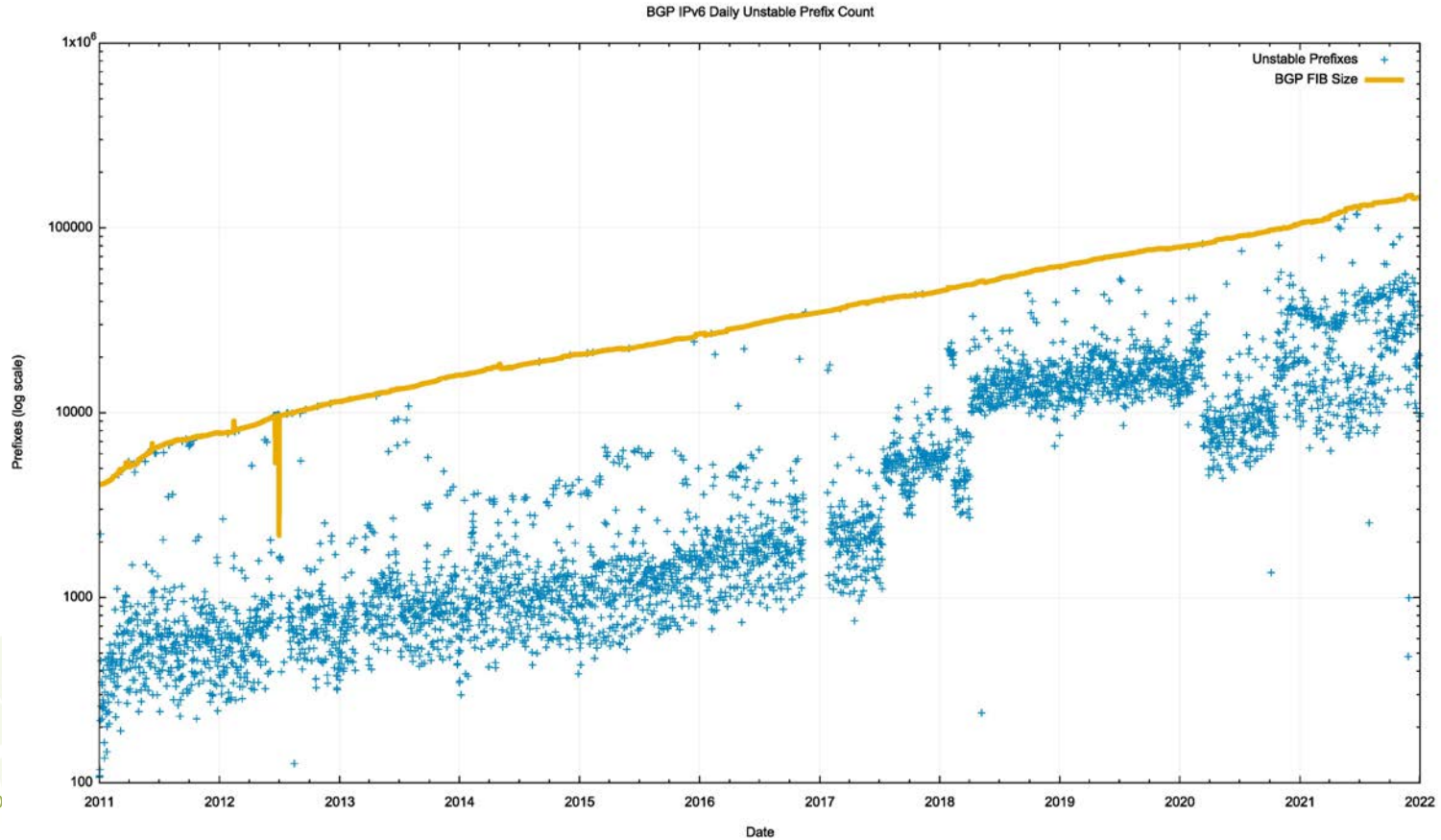
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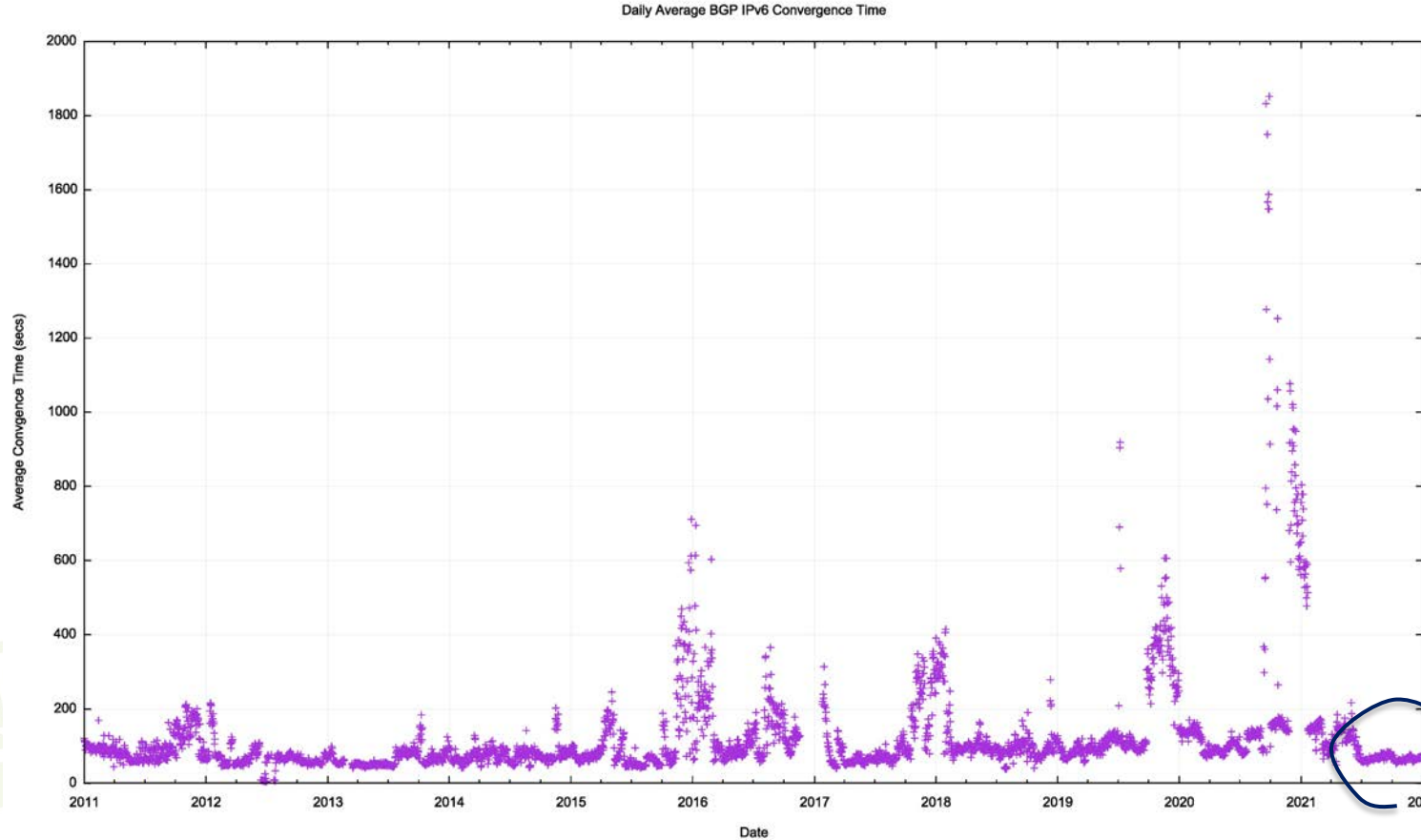
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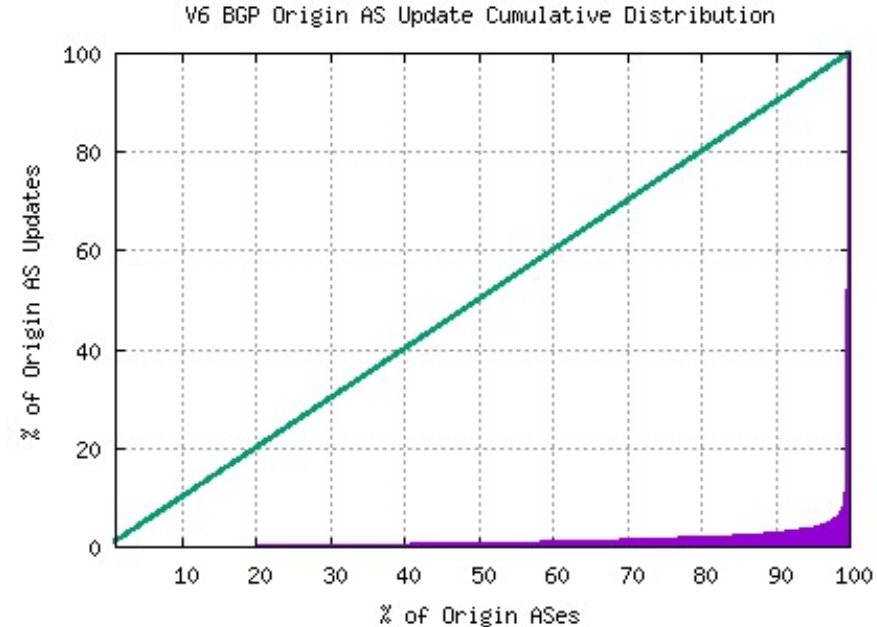
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- Review your IPv4 / IPv6 portioning in the FIB tables - a dual-stack eBGP router will need 1M 32-bit IPv4 slots and 233K 128-bit IPv6 slots for a full eBGP routing table in line cards in 2 years time if they are using a full eBGP FIB load (plus internal routes of course). That's the same memory footprint for IPv4 and IPv6!



Some Practical Suggestions

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Default routes can be helpful

- Judicious use of **default** routes in your internal network may allow you drop this requirement significantly



Some Practical Suggestions

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Time for hot caching in line card FIBs?

- Using a hot cache for line card FIB cache would reduce the high-speed TCAM memory requirement significantly without visible performance cost



Some Practical Suggestions

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The logo for APRICOT 2022 APNIC 53 features the word "APRICOT" in large white letters, "2022" in yellow above it, and "APNIC 53" in white below it. The background is a vibrant green with a repeating pattern of stylized apricot leaves and flowers, some filled with yellow and white stripes. On the left, there is a faint, larger-scale version of the same pattern.

APRICOT

2022

APNIC 53

21 February – 3 March 2022

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